FUEL ADDITIVE SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation-in-part of related application Serial No. 09/733,603, filed December 8, 2000, entitled "FUEL ADDITIVE COMPOSITION AND PROCESS/METHOD OF MAKING SAME", which is related to prior provisional application Serial No. 60/170,123, filed December 10, 1999, entitled "FUEL ADDITIVE COMPOSITION AND PROCESS/METHOD OF MAKING SAME", the contents of which are incorporated herein by this reference and are not admitted to be prior art with respect to the present invention by their mention in this cross-reference section.

BACKGROUND

This invention pertains to fuel additive compositions and methods for making fuel additive compositions. This invention further pertains to methods of using, selling, and distributing fuel additive compositions. This invention further pertains to fuel additive compositions formulated without lead. This invention further relates to fuel additive compositions for gasoline and diesel fuels. This invention further pertains to comprehensive fuel additive compositions. This invention further pertains to comprehensive fuel additive compositions tailored to the fuel additive requirements of underdeveloped nations.

Internal combustion engines typically use gasoline or diesel fuel. Gasoline is a complex mixture of relatively volatile hydrocarbons (typically C7 to C11) with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10 percent recovery point to 365 to 374 degrees Fahrenheit at the 90 percent recovery point. "Motor Gasoline" includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline. Conventional gasoline is gasoline as refined without additives. Oxygenated gasoline is finished motor gasoline, other than reformulated gasoline, having oxygen content of 2.7 percent or higher by weight. Reformulated gasoline is finished motor gasoline formulated for use in motor vehicles, the composition and properties of which meet the requirements of the reformulated gasoline regulations promulgated by the U.S. Environmental Protection Agency under Section 211(k) of the Clean Air Act. For purposes of this application, the term "gasoline" refers to any mixture of fuel, particularly motor gasoline, which will run a standard internal combustion automobile engine.

Diesel fuel specifications include ASTM D 975 and EPA regulations in 40 CFR Part 80 and 40 CFR Section 69.51. Typically, diesel fuel is a complex mixture of relatively volatile

hydrocarbons with or without small quantities of additives; diesel fuels use larger hydrocarbons than gasoline uses, particularly C12 to C30 hydrocarbons, resulting in a higher boiling range than conventional gasoline, about 340 to 650 degrees Fahrenheit. However, many other liquid fuels are also used to fuel diesel engines, including vegetable oil (biodeisel). For the purposes of this application, the term "diesel fuel" refers to any liquid fuel that will run a diesel engine.

For the purposes of this application, gasoline and diesel fuel comprise "transportation fuels." In underdeveloped countries (such as, for example, Bangladesh, China, Jordan, India, the Czech Republic, etc.) the quality of transportation fuel can be significantly lower than the quality of transportation fuel in developed countries. Many underdeveloped countries have their own refineries, which are typically old and using outdated technology. Such refineries may provide transportation fuels with significant impurities and highly varying compositions over time, to the detriment of consumers. Refineries in underdeveloped countries are often owned and run by the government, such that there is no profit motive to improve the refinery. Many other underdeveloped countries have no refinery facility and import their transportation fuels from nearby countries at the lowest possible cost, resulting in the same quality problems or worse. For underdeveloped countries with refineries, it may be economically impossible to upgrade the refinery to produce higher quality, consistent transportation fuels. Due to technological and cost considerations, these low-quality fuels typically contain few additives, resulting in even poorer consumer satisfaction. Many additives must be added to the transportation fuel during the refining process, often with expensive additive injector hardware. Many additives that are used in underdeveloped countries, such as lead, are hazardous to consumers and cause long-term pollution problems.

Some underdeveloped countries are trying to improve quality of life by implementing fuel quality standards, which have been lacking or very lax in the past. However, there has been no universal means of inexpensively increasing fuel quality to meet these new standards, and the new standards will not be met if it is not economically possible to do so. Low-quality fuels are relatively inexpensive and simple to produce, but they cause premature engine wear and low fuel efficiency, resulting in increased vehicle maintenance expense and pollution. Pollution in turn causes a lowered quality of life and additional expenses for medical care and cleanup. Large cities are particularly affected. For example, in Mexico City, air pollution, primarily from vehicle emissions, can cause daily health damage equivalent to smoking two packs of cigarettes a day.

A comprehensive system of transportation fuel additives could compensate for most or all of the fuel problems inherent in low-quality fuels in underdeveloped countries.

OBJECTS AND FEATURES OF THE INVENTION

It is an object and feature of this invention to provide a comprehensive-single-addition transportation fuel additive. It is a further object and feature of this invention to provide a comprehensive transportation fuel additive that can be tailored to the needs of local fuels. It is a further object and feature of this invention to provide a comprehensive fuel additive that compensates for the low quality of transportation fuels in underdeveloped countries. It is a further object and feature of this invention to provide a comprehensive fuel additive that is easy to add to finished fuels. It is a further object and feature of the present invention to provide comprehensive fuel additive systems for motor and diesel fuels. It is yet a further object and feature of this invention to provide useful means of selling and distributing the comprehensive fuel additive.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment hereof, this invention provides a fuel additive system, for comprehensive-single-addition improvement of low-quality transportation fuels, comprising: at least one amount of at least one additive component sufficient to effectively enhance biocidal action; at least one amount of at least one additive component sufficient to effectively enhance combustion boosting action; at least one amount of at least one additive component sufficient to effectively enhance corrosion inhibiting action; at least one amount of at least one additive component sufficient to effectively enhance water managing action; at least one amount of at least one additive component sufficient to effectively enhance detergent action; at least one amount of at least one additive component sufficient to effectively enhance solvent action; at least one amount of at least one additive component sufficient to effectively enhance fuel stabilizing action; and at least one amount of at least one additive component sufficient to effectively enhance fuel lubricating action; wherein at least one user-friendly, effective, additive may be provided for adding to transportation fuels. Moreover, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action. Additionally, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action. Also, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action. In addition, it provides such a fuel additive system further comprising the low-quality transportation fuels. And, it provides such a fuel additive system

wherein such at least one amounts of such at least one additive components totally comprise a volume ratio with respect to transportation fuels of about 1:1000.

Further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein: said at least one amount of such at least one additive component sufficient to effectively enhance biocidal action comprises from about 0.2 to about 7 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance combustion boosting action comprises from about 1 to about 5 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises from about 0.2 to about 5 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance water managing action comprises from about 2 to about 8 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance detergent action comprises from about 20 to about 45 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance solvent action comprises from about 46 to about 80 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises from about 0.2 to about 5 volume percent; and said at least one amount of such at least one additive component sufficient to effectively enhance fuel lubricating action comprises from about 0.5 to about 5 volume percent; wherein at least one user-friendly, effective, additive may be provided for adding to motor fuels. Even further, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0002 to about 9 volume percent. Moreover, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 5 to about 10 volume percent. Additionally, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0002 to about 9 volume percent; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about from 5 to about 10 volume percent.

Also, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein: said at least one amount of such at least one additive component sufficient to effectively enhance biocidal action comprises from about 0.6 to about 5 volume percent; said at least one amount of such at least one additive component

sufficient to effectively enhance combustion boosting action comprises from about 2 to about 4 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises from about 1 to about 2.5 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance water managing action comprises from about 2 to about 6 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance detergent action comprises from about 26 to about 35 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance solvent action comprises from about 52 to about 59 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises from about 1 to about 2.5 volume percent; and said at least one amount of such at least one additive component sufficient to effectively enhance fuel lubricating action comprises from about 1.5 to about 2.5 volume percent. In addition, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0004 to about 6 volume percent. And, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 6 to about 8 volume percent. Further, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0004 to about 6 volume percent; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 6 to about 8 volume percent.

Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein: said at least one amount of such at least one additive component sufficient to effectively enhance biocidal action comprises about 4 volume percent 1,2,4-trimethylbenzene; said at least one amount of such at least one additive component sufficient to effectively enhance combustion boosting action comprises about 3 volume percent cumene; said at least one amount of such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises about 2 volume percent DCI 6A™; said at least one amount of such at least one additive component sufficient to effectively enhance water managing action comprises about 3 volume percent 2-butoxyethanol; said at least one amount of such at least one additive component sufficient to effectively enhance detergent action comprises about 20 volume percent DMA 558™ and about 6 volume

percent 2,4-pentanedione; said at least one amount of such at least one additive component sufficient to effectively enhance solvent action comprises about 50 volume percent xylene and about 2 volume percent n-propylbenzene; said at least one amount of such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises about 2 volume percent AO 22™; and said at least one amount of such at least one additive component sufficient to effectively enhance fuel lubricating action comprises about 2 volume percent DCI 6A™. Moreover, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising about 2 volume percent ferrocene. Additionally, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising about 6 volume percent methanol. Also, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising about 2 volume percent ferrocene; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 6 volume percent methanol.

In addition, it provides such a fuel additive system, Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, comprising: at least one amount of at least one additive component sufficient to effectively enhance biocidal action; at least one amount of at least one additive component sufficient to effectively enhance combustion boosting action; at least one amount of at least one additive component sufficient to effectively enhance corrosion inhibiting action; at least one amount of at least one additive component sufficient to effectively enhance water managing action; at least one amount of at least one additive component sufficient to effectively enhance detergent action; at least one amount of at least one additive component sufficient to effectively enhance solvent action; at least one amount of at least one additive component sufficient to effectively enhance fuel stabilizing action; and at least one amount of at least one additive component sufficient to effectively enhance fuel lubricating action; wherein at least one user-friendly, effective, additive may be provided for adding to diesel fuels. And, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action. Further, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action. Even further, it provides such a fuel additive system further comprising: at least one amount of at least one additive

component sufficient to effectively enhance combustion modifying action; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action.

Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein: said at least one amount of such at least one additive component sufficient to effectively enhance biocidal action comprises from about 0.1 to about 2 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance combustion boosting action comprises from about 31 to about 65 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises from about 0.25 to about 1 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance water managing action comprises from about 5 to about 15 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance detergent action comprises from about 10 to about 30 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance solvent action comprises from about 22 to about 60 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises from about 5 to about 10 volume percent; and wherein such at least one amount of such at least one additive component sufficient to effectively enhance fuel lubricating action comprises from about 1.2 to about 2.5 volume percent. Moreover, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0002 to about 9 volume percent. Additionally, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 2 to about 45 volume percent. Also, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0002 to about 9 volume percent; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 2 to about 45 volume percent.

In addition, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein: said at least one amount of such at least one additive component sufficient to effectively enhance biocidal action comprises from about 0.5 to about 1 volume percent; said at least one amount of such at least one additive component

sufficient to effectively enhance combustion boosting action comprises from about 31 to about 43 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises from about 0.5 to about 0.75 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance water managing action comprises from about 5 to about 10 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance detergent action comprises from about 10 to about 20 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance solvent action comprises from about 22 to about 45 volume percent; said at least one amount of such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises from about 5 to about 7 volume percent; and wherein such at least one amount of such at least one additive component sufficient to effectively enhance fuel lubricating action comprises from about 1.5 to about 2 volume percent. And, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0004 to about 6 volume percent. Further, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 5 to about 31 volume percent. Even further, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising from about 0.0004 to about 6 volume percent; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising from about 5 to about 31 volume percent.

Moreover, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein: said at least one amount of such at least one additive component sufficient to effectively enhance biocidal action comprises about 1 volume percent T9312™; said at least one amount of such at least one additive component sufficient to effectively enhance combustion boosting action comprises about 30 volume percent 2-ethylhexyl nitrate and also comprises about 2 volume percent 2-ethylhexyl alcohol; said at least one amount of such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises about 0.5 volume percent DCI 6A™; said at least one amount of such at least one additive component sufficient to effectively enhance water managing action comprises about 5 volume percent DMA 451™; said at least one amount of such at least one additive component sufficient to effectively enhance detergent action comprises about 5 volume

percent DMA 451™; said at least one amount of such at least one additive component sufficient to effectively enhance solvent action comprises about 20 volume percent AROL 50™ and also comprises about 2.5 volume percent heavy aromatic naptha; said at least one amount of such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises about 5 volume percent DMA 558™; and wherein such at least one amount of such at least one additive component sufficient to effectively enhance fuel lubricating action comprises about 2 volume percent OLI 5015™. Additionally, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising about 2 volume percent ferrocene. Also, it provides such a fuel additive system further comprising at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising about 20 volume percent vinyl acetate polymers. In addition, it provides such a fuel additive system further comprising: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action comprising about 2 volume percent ferrocene; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action comprising about 20 volume percent vinyl acetate polymers.

And, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance combustion boosting action comprises at least one additive component selected from the group consisting essentially of: methyl tert-butyl ether, ethyl tert-butyl ether, tert-amyl methyl ether, diisopropyl ether, tert-amyl alcohol, tert-butyl alcohol, methanol, ethanol, isopropanol, n-propylbenzene, toluene, xylene, benzene, nitromethane, nitroethane, propylene oxide, naptha, alcohols, ethers, and cumene. Further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises at least one additive component selected from the group consisting essentially of: DCI series products, DCI 6A™, DCI 4A™, DCI 11™, DCI 28™, DCI 30™, HITEC 580™, BIOBOR JF™, and ONDEO-NALCO 5403™. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance water managing action comprises at least one additive component selected from the group consisting essentially of: 2-butoxyethanol, methanol, ethanol, isopropyl alcohol, alcohols, ethers, water scavengers, and DMA 451™. Moreover, it provides such a fuel additive system, for

comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance detergent action comprises at least one additive component selected from the group consisting essentially of: DMA 558™, DMA series products, amines, polyisobutyleneamine, polyetheramine, polyalkyl amines, polyether amines, polyalkyl succinimides, polyalkylaminophenols, sulfonate, phosphonate, thiophosphonate, phenate, salicylate, 2,4-pentanedione, and 2,3-pentanedione. Additionally, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance solvent action comprises at least one additive component selected from the group consisting essentially of: xylene, toluene, benzene, naptha, cumene, and n-propylbenzene. Also, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises at least one additive component selected from the group consisting essentially of: AO 22™, AO series products, alkylated phenols, diamines, surfactants, dispersants, 2,4-pentanedione, 2,3-pentanedione, and amines. In addition, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance biocide action comprises at least one additive component selected from the group consisting essentially of: 1,2,4-trimethylbenzene, thiazoles, thiocyanates, isothiazolins, cyanobutane, dithiocarbamate, thione, bromo-compounds, surfactants, water-scavengers, ONDEO-NALCO 303MC™, and BIOBOR JF™. And, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance fuel lubricating action comprises at least one additive component selected from the group consisting essentially of: DCI 6A™, DCI™ series products, AO™ series products, oils, polyalphaolefins, sulfur, ONDEO-NALCO 5403, and lubricants. Further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance combustion modifying action comprises at least one additive component selected from the group consisting essentially of: ferrocene, platinum, cerium, manganese, methylcyclopentadienyl manganese tricarbonyl, and HITEC 3023™. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality motor fuels, wherein such at least one additive component sufficient to effectively enhance low temperature flowing action comprises at least one additive component selected from the group consisting essentially of: methanol, n-propanol, isopropanol, polyalkyl

methacrylate, polystyrene methacrylate, polymethacrylates, polymers, dispersants, wax modifiers, alcohols, and 2-butoxyethanol.

Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance combustion boosting action comprises at least one additive component selected from the group consisting essentially of: 2-ethylhexyl nitrate, 2-ethylhexyl alcohol, cumene, n-propylbenzene, toluene, xylene, benzene, nitromethane, nitroethane, propylene oxide, ethanol, octyl nitrate, naptha, methyl tert-butyl ether, ethyl tert-butyl ether, tert-amyl methyl ether, diisopropyl ether, tert-amyl alcohol, tert-butyl alcohol, methanol, isopropyl alcohol, tert-butyl alcohol, tert-amyl alcohol, alcohols, and ethers. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance corrosion inhibiting action comprises at least one additive component selected from the group consisting essentially of: DCI 4A™, DCI 6A™, DCI 11™, DCI 28™, DCI 30™, HI TEC 580™, BIOBOR JF™, ONDEO-NALCO 5403™, azoles, amines, nitrites, phosphates, molybdates, phosphonates, and silicates. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance water managing action comprises at least one additive component selected from the group consisting essentially of: DMA 451™, DDA-4500™, HITEC 6471™, HITEC 6423™, ALKEN EVEN FLO 910™, Alcohols, 2-butoxyethanol, and water scavengers. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance detergent action comprises at least one additive component selected from the group consisting essentially of: DMA 451™, DMA series products, DMA 558™, DMA 559™, DMA 560™, DMA 561™, DMA 562™, DMA 563™, DMA 564™, amines, polyisobutyleneamine, polyetheramine, polyalkyl amines, polyether amines, polyalkyl succinimides, polyalkylaminophenols, sulfonates, phosphonates, thiophosphonates, phenates, salicylates, 2,4-pentanedione, and 2,3-pentanedione. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance solvent action comprises at least one additive component selected from the group consisting essentially of: AROL 50™, HISOL 100™, benzene, xylene, toluene, cumene, naptha, heavy aromatic naptha, and n-propylbenzene. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels,

wherein such at least one additive component sufficient to effectively enhance fuel stabilizing action comprises at least one additive component selected from the group consisting essentially of: DMA 558™, DMA™ series products, 2,3-pentanedione, 2,4-pentanedione, amines, dispersants, and surfactants. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance biocide action comprises at least one additive component selected from the group consisting essentially of: T9312™, T9360™, 1,2,4-trimethylbenzene, KATHON 886™, BIOBOR JF™, ONDEO-NALCO 303MC™, thiazoles, thiocyanates, isothiazolins, cyanobutane, dithiocarbamate, thione, bromo-compounds, surfactants, and water-scavengers. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance fuel lubricating action comprises at least one additive component selected from the group consisting essentially of: OLI 5015™, All AO™ series products, All DCI™ series products, All OLI-5000™ series products, All OLI-9000™ series products, ONDEO-NALCO 5403™, HITEC 580™, oils, polyalphaolefins, and sulfur. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance combustion modifying action comprises at least one additive component selected from the group consisting essentially of: ferrocene, platinum, cerium, manganese, methylcyclopentadienyl manganese tricarbonyl, HITEC 3023™, ALKEN EVEN FLO 910™, and nitromethane. Even further, it provides such a fuel additive system, for comprehensive-single-addition improvement of low-quality diesel fuels, wherein such at least one additive component sufficient to effectively enhance low temperature flowing action comprises at least one additive component selected from the group consisting essentially of: alcohols, methanol, n-propanol, 2-butoxyethanol, isopropanol, polyalkyl methacrylate, polystyrene methacrylate, polymethacrylates, polymers, dispersants, wax modifiers, and vinyl acetate polymers.

In accordance with another preferred embodiment hereof, this invention provides a method of making a fuel additive system, for comprehensive-single-addition improvement of low-quality transportation fuels, comprising the step of mixing the following ingredients: at least one amount of at least one additive component sufficient to effectively enhance biocidal action; at least one amount of at least one additive component sufficient to effectively enhance combustion boosting action; at least one amount of at least one additive component sufficient to effectively enhance corrosion inhibiting action; at least one amount of at least one additive

component sufficient to effectively enhance water managing action; at least one amount of at least one additive component sufficient to effectively enhance detergent action; at least one amount of at least one additive component sufficient to effectively enhance solvent action; at least one amount of at least one additive component sufficient to effectively enhance fuel stabilizing action; and at least one amount of at least one additive component sufficient to effectively enhance fuel lubricating action; wherein at least one user-friendly, effective, additive may be provided for adding to transportation fuels. Even further, it provides such a method of making a fuel additive system wherein such step further comprises mixing in at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action. Even further, it provides such a method of making a fuel additive system wherein such step further comprises mixing in at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action. Even further, it provides such a fuel additive system wherein such step further comprises mixing in: at least one amount of at least one additive component sufficient to effectively enhance combustion modifying action; and at least one amount of at least one additive component sufficient to effectively enhance low temperature flowing action. Even further, it provides such a fuel additive system further comprising the step of mixing in low-quality transportation fuels. Even further, it provides such a fuel additive system wherein such at least one amounts of such at least one additive components totally comprise a volume ratio with respect to such low-quality transportation fuels of about 1:1000.

In accordance with another preferred embodiment hereof, this invention provides a method of providing comprehensive fuel additives to at least one political entity in order to ameliorate the deleterious effects of low quality transportation fuels, in relation to at least one transportation fuel being used within such at least one political entity, comprising the steps of: presenting to targeted such at least one political entity at least one demonstration testing plan for such at least one comprehensive fuel additive to demonstrate effectiveness; based upon results of any such demonstration testing, modifying at least one formula of such at least one comprehensive fuel additive for improved effectiveness; and transporting to such political entity in quantity such at least one upgraded formula for use with such transportation fuels. Even further, it provides such a method further comprising the step of providing instructions for use of such at least one upgraded formula with each unit of such at least one transportation fuel. Even further, it provides such a method further comprising the step of recursively improving such at least one formula of such at least one comprehensive fuel additive to provide at least one upgraded formula for at least one region for such at least one political entity. Even further,

it provides such a method wherein such comprehensive fuel additives comprise: at least one combustion booster; at least one corrosion inhibitor; at least one water manager, at least one detergent; at least one biocide; at least one stabilizer; and at least one lubricant. Even further, it provides such a method wherein such comprehensive fuel additives further comprise at least one low temperature additive. Even further, it provides such a method wherein such comprehensive fuel additives further comprise at least one combustion modifier.

In accordance with another preferred embodiment hereof, this invention provides a method of developing comprehensive fuel additives for at least one political entity in order to ameliorate the deleterious effects of low-quality transportation fuels comprising the steps of: identifying at least one comprehensive set of fuel additive ingredients useful together to ameliorate the deleterious effects of such low-quality transportation fuels; identifying, by theory and testing of such low-quality transportation fuels, at least one formula comprising at least one component additive quantity of each such at least one comprehensive set of fuel additive ingredients; identifying, for a particular at least one political entity, at least one potentially useful initial such at least one formula for demonstration testing to demonstrate effectiveness; and if improvement to such initial such at least one formula is desired, modifying such initial such at least one formula to provide at least one upgraded formula. Even further, it provides such a method wherein such at least one comprehensive set of fuel additive ingredients comprise: at least one combustion booster; at least one corrosion inhibitor; at least one water manager, at least one detergent; at least one biocide; at least one stabilizer; and at least one lubricant. Even further, it provides such a method wherein such comprehensive fuel additives further comprise at least one low temperature additive. Even further, it provides such a method wherein such comprehensive fuel additives further comprise at least one combustion modifier.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 2 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 3 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 4 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 5 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 6 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 7 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 8 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 9 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 10 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 11 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 12 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 13 shows a corroded injector tip with carbon deposits.

FIG. 14 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 15 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 16 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 17 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 18 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 19 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 20 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 21 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 22 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 23 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 24 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 25 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 26 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 27 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 28 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 29 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 30 shows an overview of the catalytic cycle in fuel combustion.

FIG. 31 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 32 shows the results of tests on a preferred embodiment of a comprehensive fuel additive of the present invention.

FIG. 33 shows an example of a fuel storage tank with a mixer that may be used to mix the comprehensive fuel additive of the present invention with stored fuel.

FIG. 34 illustrates aspects of preferred systems and methods of marketing and doing business with respect to the comprehensive fuel additives of this invention.

FIG. 35 illustrates further aspects of preferred systems and methods of marketing and doing business with respect to the comprehensive fuel additives of this invention.

DETAILED DESCRIPTION OF THE BEST MODE AND PREFERRED EMBODIMENTS OF THE INVENTION

Fuel additives can be used to correct or lessen the impact of low-quality transportation fuels. For example, additives may improve low octane or cetane, improve cold flow properties, clean injectors fouled by impurities, prevent fuel oxidation in storage, prevent microbial contamination, improve combustion efficiency, and prevent fuel system corrosion. Other additives may increase the oxygen content of fuels in order to promote complete combustion and to lower pollution levels.

A preferred formula of the fuel additive system, for comprehensive-single-addition improvement of low-quality transportation fuels, of the present invention comprises additive components comprising at least one combustion modifier, at least one corrosion inhibitor, at least one water demulsifier (i.e., water manager), at least one detergent, at least one solvent, at least one fuel stabilizer, at least one biocide, and at least one fuel lubricant. Under appropriate circumstances, where desired, the preferred formula may also comprise at least one octane booster (i.e., combustion booster). Under appropriate circumstances, such as, for example, use in cold climates, the preferred formula may also comprise at least one low temperature additive. The comprehensive fuel additives of the present invention have a novel capability of substantially correcting, with a single user-friendly addition of such additives, all of the detrimental aspects of low-quality transportation fuels. The comprehensive fuel additive formula is preferably tailored and adjusted to meet local needs. Different, but closely related, comprehensive fuel additive formulas are used for motor fuels and diesel fuels.

Comprehensive motor fuel additives of the present invention will be discussed first. Octane is a measure of the combustion speed of gasoline. Vehicles are designed to operate on fuel with a particular octane (such as, for example, 87, 89, 91, or 92) and refineries refine multiple transportation fuels with the required octanes. Octane can be adjusted by varying the hydrocarbon composition of the base fuel, by oxygenating the fuel, or by adding additives (combustion boosters). Low-quality fuels may have low octane due to insufficient control of the hydrocarbon content of the base fuel or the lack of availability of octane boosting additives. Using fuel with the wrong octane for the vehicle can result in stalling, knocking, inefficient combustion, and low fuel economy. Adding oxygenates to gasoline boosts the gasoline's octane rating and reduces atmospheric pollution associated with automobile emissions by making more oxygen available for combustion. Examples of fuel oxygenates are: methyl tert-butyl ether

(MTBE), ethyl tert-butyl ether (ETBE), tert-amyl methyl ether (TAME), diisopropyl ether (DIPE), tert-amyl alcohol (TAA), tert-butyl alcohol (TBA), methanol, isopropyl alcohol, and ethanol. Other octane boosters function by slowing the combustion of the fuel by providing especially high flash-point hydrocarbons to the fuel. Such octane boosting hydrocarbons include cumene, toluene, benzene, naptha, and xylene. These high flash-point solvent hydrocarbons also have the advantage of serving as fuel injector cleaners before combusting.

A preferred comprehensive motor fuel additive of the present invention comprises at least one of the following octane boosters: methyl tert-butyl ether (MTBE), ethyl tert-butyl ether (ETBE), tert-amyl methyl ether (TAME), diisopropyl ether (DIPE), tert-amyl alcohol (TAA), tert-butyl alcohol (TBA), methanol, ethanol, isopropyl alcohol, cumene, n-propylbenzene, toluene, xylene, benzene, nitromethane, nitroethane, propylene oxide, alcohols, ethers, and/or naptha. The octane boosters disclosed above may comprise about 0.5 to 5.5% by volume of the comprehensive motor fuel additive. Preferably, the octane boosters disclosed above may comprise (all ranges set forth herein are from an approximate lower amount to an approximate higher amount) about 1 to 5% by volume of the motor fuel additive. More preferably, the octane boosters disclosed above may comprise about 2 to 4% by volume of the motor fuel additive. Most preferably, the octane boosters disclosed above may comprise about 3% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 3% cumene, by volume. It is an object and feature of the present invention that the composition and volume percent of the octane booster (combustion booster) will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other octane boosters, such as, for example, other solvents, nitrous oxide, hydrazine, etc., may suffice. Combustion modifiers function by chemically modifying the combustion of the fuel, to slow burning, speed up burning, or enhance complete combustion. Such combustion modifiers include ferrocene, manganese, platinum, cerium, methylcyclopentadienyl manganese tricarbonyl, or HITEC 3023™ (all trademarked names used herein correspond to those listed in the list of registered gasoline and diesel additives published by the United States Environmental Protection Agency, available at www.epa.gov/otaq/fuels). A comprehensive motor fuel additive of the present invention comprises at least one of the following combustion modifiers: ferrocene, manganese, methylcyclopentadienyl manganese tricarbonyl, platinum, cerium, and/or HITEC 3023™. The combustion modifier manganese may comprise about 4 to 45 ppm

(parts per million) of the motor fuel additive. Preferably, the combustion modifier manganese may comprise about 10 to 40 ppm of the motor fuel additive. More preferably, the combustion modifier manganese may comprise about 20 to 30 ppm of the motor fuel additive. The combustion modifiers platinum and/or cerium may comprise about 1 to 15 ppm of the motor fuel additive. Preferably, the combustion modifiers platinum and/or cerium may comprise about 2 to 12 ppm of the motor fuel additive. More preferably, the combustion modifiers platinum and/or cerium may comprise about 4 to 10 ppm of the motor fuel additive. The combustion modifier HITEC 3023™ may comprise about 2 to 10% of the motor fuel additive. Preferably, the combustion modifier HITEC 3023™ may comprise about 3 to 9% of the motor fuel additive. More preferably, the combustion modifier HITEC 3023™ may comprise about 5 to 6% of the motor fuel additive. The combustion modifier ferrocene (dicyclopentadienyl iron) may comprise about 0.5 to 6 volume percent, of a 10% ferrocene liquid concentrate, of the motor fuel additive. Preferably, the combustion modifier ferrocene may comprise about 1 to 5 volume percent, of a 10% ferrocene liquid concentrate, of the motor fuel additive. More preferably, the combustion modifier ferrocene may comprise about 2 to 4 volume percent, of a 10% ferrocene liquid concentrate, of the motor fuel additive. In the best mode, for typical circumstances, the combustion modifier component of the motor fuel additive is 3%, of a 10% ferrocene liquid concentrate, by volume. It is an object and feature of the present invention that the composition and volume percent of the combustion modifier will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc, of the customer. Upon reading this specification, those of ordinary skill in this art will understand that under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other combustion modifiers, such as ferrocene in other forms than in a liquid concentrate, chemical compounds of manganese, platinum, or cerium, or other metals, may suffice.

Corrosion inhibitors typically coat the internal surfaces of the engine and fuel system to prevent water, ethanol, and other corrosive substances from contacting the fuel system surfaces. There are several types of corrosion inhibitors. Polar compounds wet the metal surface preferentially, protecting it with a film of oil. Other compounds may absorb water by incorporating it in a water-in-oil emulsion so that only the oil touches the metal surface. Another type of corrosion inhibitor combines chemically with the metal to present a non-reactive surface. Typical corrosion inhibitors used in vehicles include organic molecules, azoles, amines, nitrites, phosphates, molybdates, phosphonates, and silicates. A preferred comprehensive fuel additive of the present invention preferably comprises at least one of the

following corrosion inhibitors: DCI series products, DCI 4A ™, DCI 6A ™, DCI 11 ™, DCI 28 ™, DCI 30 ™, HITEC 580 ™, BIOBOR JF™, or ONDEO-NALCO 5403 ™. Preferably, the corrosion inhibitors disclosed above are present as about 0.1 to 5.1% by volume of the motor fuel additive. More preferably, the corrosion inhibitors disclosed above are present as about 0.2 to 5% by volume of the motor fuel additive. Most preferably, the corrosion inhibitors disclosed above are present as about 1 to 2.5% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 1.5% DCI 6A™, by volume. It is an object and feature of the present invention that the composition and volume percent of the corrosion inhibitor will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc, of the customer. Upon reading this specification, those of ordinary skill in this art will understand that under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other corrosion inhibitors, such as the components of the above mentioned trademarked corrosion inhibitors in other forms or from other sources, organic molecules, azoles, amines, nitrites, phosphates, molybdates, phosphonates, and silicates, may suffice.

Water droplets in fuel can damage fuel injectors by explosively vaporizing at the tip of hot fuel injectors. For water-contaminated fuel, water-managing additives may be used to emulsify the water and incorporate the water harmlessly into the fuel, or water-managing additives may be used to force water out of solution and drop to the bottom of the storage tank. Water on the bottom of storage tanks must be periodically removed to prevent corrosion, microbial contamination, and to reclaim lost fuel storage space. Also, water-binding additives may be used which chemically bind with water molecules to harmlessly move the water through the fuel system; substantially anhydrous alcohols may be used for this purpose. Exemplary alcohols include 2-butoxyethanol, methanol, ethanol, and/or isopropyl alcohol. A preferred comprehensive water manager of the present invention comprises at least one of the following water managers: 2-butoxyethanol, methanol, ethanol, isopropyl alcohol, alcohols, ethers, water scavengers, and/or DMA 451™. Preferably, the water managers disclosed above are present as about 1 to 10% by volume of the motor fuel additive. More preferably, the water managers disclosed above are present as about 2 to 8% by volume of the motor fuel additive. Most preferably, the water managers disclosed above are present as about 2 to 6% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 5% 2-butoxyethanol, by volume, to manage water. It is an object and feature of the present invention that the composition and volume percent of the water manager will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet,

pollution composition, etc, of the customer. Upon reading this specification, those of ordinary skill in this art will understand that under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other water managers, such as other alcohols, ethers, etc., may suffice.

Fuel detergents clean fuel injectors and valves of carbon deposits, improving engine efficiency. Detergents help control varnish, ring zone deposits, and rust by keeping insoluble particles in colloidal suspension and in some cases, by neutralizing acids. Detergents are commonly metallic (commonly barium, calcium, or magnesium) compounds, such as sulfonates, phosphonates, thiophosphonates, phenates, or salicylates. Metallic detergents create a metallic ash byproduct after combustion. Another class of fuel system detergent are amines, such as, for example, polyalkyl amines, polyether amines, polyalkyl succinimides, and polyalkylaminophenols. Amine detergents have the advantage of not producing metallic ash byproducts. BASF's Polyisobutyleneamine (PIBA), and Polyetheramine (PEA) are two commercially available examples. A comprehensive fuel additive of the present invention comprises at least one of the following detergents: DMA series products, DMA 558™, DMA 559™, DMA 560™, DMA 561™, DMA 562™, DMA 563™, DMA 564™, amines, polyalkyl amines, polyether amines, polyalkyl succinimides, polyalkylaminophenols, Polyisobutyleneamine (PIBA), Polyetheramine (PEA), sulfonates, phosphonates, thiophosphonates, phenates, and/or salicylates. Preferably, the detergents disclosed above are present as about 10 to 35% by volume of the motor fuel additive. More preferably, the detergents disclosed above are present as about 15 to 30% by volume of the motor fuel additive. More preferably, the detergents disclosed above are present as about 20 to 25% by volume of the motor fuel additive. Most preferably, the detergents disclosed above are present as about 25% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 25% DMA 558™, by volume. Preferably, a comprehensive fuel additive of the present invention also comprises yet another detergent, 2,3-pentanedione. Preferably, 2,3-pentanedione is present as about 4 to 20% by volume of the motor fuel additive. More preferably, 2,3-pentanedione is present as about 5 to 15% by volume of the motor fuel additive. More preferably 2,3-pentanedione is present as about 6 to 10% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 6% 2,3-pentanedione, by volume. It is an object and feature of the present invention that the composition and volume percent of the detergent will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc, of the customer. Upon reading this specification, those of ordinary skill in this art will understand

that under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other fuel injector detergents and cleaners, such as the components of the above mentioned trademarked detergents in other forms or from other sources, other fuel system detergents, other amines, etc., may suffice.

Solvents are added to form a base in which the other constituents of the comprehensive fuel additive may be dissolved. Also, solvents are effective for dissolving and removing fuel system deposits. A comprehensive fuel additive of the present invention comprises at least one of the following solvents: xylene, toluene, benzene, naptha, and/or cumene. Preferably, the solvents disclosed above are present as about 40 to 80% by volume of the motor fuel additive. More preferably, the solvents disclosed above are present as about 45 to 75% by volume of the motor fuel additive. More preferably the solvents disclosed above are present as about 50 to 55% by volume of the comprehensive motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 50% xylene, by volume. Preferably, a comprehensive fuel additive of the present invention also comprises the solvent n-propylbenzene. Preferably, n-propylbenzene is present as about 0.5 to 5.5% by volume of the motor fuel additive. More preferably, n-propylbenzene is present as about 1 to 5% by volume of the motor fuel additive. More preferably n-propylbenzene is present as about 2 to 4% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive is about 2% n-propylbenzene, by volume. It is an object and feature of the present invention that the composition and volume percent of the solvent will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc, of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other solvents, such as heavy aromatic naptha, hexane, etc., may suffice.

Fuel stabilizers are added to prevent fuel oxidation and deterioration during fuel storage, typically by terminating free radicals or dispersing agglomerated molecules. Preventing oxidation prevents hydrocarbons from linking together into random insoluble films that clog filters and fuel injectors. A highly oxidized fuel may be so thick and lumpy that it is not pumpable or usable. Typical fuel stabilizers include alkylated phenols, diamines, surfactants, dispersants, and amines. A comprehensive fuel additive of the present invention comprises at least one of the following fuel stabilizers: AO series products, AO 22™, AO 24™, AO 29™, AO 30™, AO 31™, AO 32™, AO 36™, AO 36D™, AO 37™, AO 37D™, alkylated phenols, surfactants, dispersants, 2,4-pentanedione, 2,3-pentanedione, diamines, and/or amines.

Preferably, the stabilizers disclosed above are present as about 0.1 to 5.1% by volume of the motor fuel additive. More preferably, the stabilizers disclosed above are present as about 0.2 to 5% by volume of the motor fuel additive. Most preferably, the stabilizers disclosed above are present as about 1.0 to 2.5% by volume of the motor fuel additive. In the best mode, for typical circumstances, the fuel stabilizer component of the motor fuel additive is about 1.5% AO 22™, by volume. It is an object and feature of the present invention that the composition and volume percent of the fuel stabilizer will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc, of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other fuel stabilizers, such as the components of the above mentioned, trademarked stabilizers in other forms or from other sources, other amines, surfactants, dispersants, detergents, etc., may suffice.

Biocides are used to kill microbes that eat hydrocarbons. Microbe-contaminated fuels have a bad smell and contain sticky strands of fungus and bacteria that clog fuel filters. Common fuel-contaminating microbes include cladosporium resinae fungus, as well as bacteria, yeast and other fungi. Microbes are most able to attack water-contaminated fuels. Some examples of fuel biocides include thiazoles, thiocyanates, isothiazolins, cyanobutane, dithiocarbamate, thione, and bromo-compounds. Surfactants and water-scavengers are also useful for preventing and curing biocontamination. A comprehensive fuel additive of the present invention comprises at least one of the following biocides: thiazoles, thiocyanates, isothiazolins, cyanobutane, dithiocarbamate, thione, bromo-compounds, ONDEO-NALCO 303MC™, and 1,2,4-trimethylbenzene. Preferably, the above disclosed biocides are present as about 0.5 to 10% by volume of the motor fuel additive. More preferably, the above disclosed biocides present as about 1 to 7% by volume of the motor fuel additive. Most preferably, the above disclosed biocides present as about 4 to 5% by volume of the motor fuel additive. Alternatively, a comprehensive fuel additive of the present invention may comprise BIOBOR JF™. Preferably, BIOBOR JF™ is present as about 0.1 to 2% by volume of the motor fuel additive. More preferably, BIOBOR JF™ is present as about 0.2 to 1% by volume of the motor fuel additive. Most preferably, BIOBOR JF™ is present as about 0.6 to 0.8% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive comprises about 5% 1,2,4-trimethylbenzene, by volume. It is a feature of the present invention that the composition and volume percent of the biocide will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition,

biocontamination level, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other biocides, such as the components of the above mentioned trademarked stabilizers in other forms or from other sources, may suffice.

A fuel system lubricant, enhancing fuel lubricating action, helps prevent wear damage in areas of the engine that are not served by the engine oil, such as, for example, the fuel injectors, fuel pump, valves, and upper combustion chambers. Fuel system lubricants are typically elements, such as sulfur, lead, or molybdenum; alternatively, oils, polyalphaolefins, lubricants, or other organic molecules may be used to provide a lubricating film between metal surfaces. A comprehensive fuel additive of the present invention comprises at least one of the following fuel system lubricants: AO series products, AO 22™, AO 24™, AO 29™, AO 30™, AO 31™, AO 32™, AO 36™, AO 36D™, AO 37™, AO 37D™, DCI series products, DCI 4A ™, DCI 6A ™, DCI 11 ™, DCI 28 ™, and DCI 30 ™, oils, polyalphaolefins, sulfur, ONDEO-NALCO 5403, and/or lubricants. Preferably, the fuel system lubricants disclosed above are present as about 0.1 to 5.1% by volume of the motor fuel additive. More preferably, the fuel system lubricants disclosed above are present as about 0.2 to 5% by volume of the motor fuel additive. Most preferably, the fuel system lubricants disclosed above are present as about 1.5 to 2.5% by volume of the motor fuel additive. In the best mode, for typical circumstances, the fuel system lubricants component of the motor fuel additive comprises about 1.5% DCI 6A™, by volume. It is an object and feature of the present invention that the composition and volume percent of the fuel system lubricant will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other fuel system lubricants, such as the components of the above mentioned trademarked stabilizers in other forms or from other sources, other metals, lead, molybdenum, manganese, etc., may suffice.

A low temperature additive keeps fuel liquid and flowing by preventing the chemical components of fuel from forming crystals and solidifying at low temperatures. Some low temperature additives prevent crystal formation. Other low temperature additives, such as, for example, polymers, methacrylates, and wax modifiers, modify crystal growth to encourage the growth of linear or tiny crystals that do not clog fuel filters. Still other low temperature additives, such as, for example, methanol, dissolve wax crystals or prevent water ice from

forming. Low temperature additives are often needed in cold climates, but are rarely used in tropical climates. A comprehensive fuel additive of the present invention may comprise at least one of the following low temperature additives: methanol, n-propanol, isopropanol, polyalkyl methacrylate, polystyrene methacrylate, polymethacrylates, polymers, dispersants, wax modifiers, alcohols, and/or 2-butoxyethanol. Preferably, the low temperature additives disclosed above are present as about 2 to 15% by volume of the motor fuel additive. More preferably, the low temperature additives disclosed above are present as about 5 to 10% by volume of the motor fuel additive. Most preferably, the low temperature additives disclosed above are present as about 6 to 8% by volume of the motor fuel additive. In the best mode, for typical circumstances, when needed, the low temperature additive component of the motor fuel additive comprises about 6% methanol, by volume. It is a feature of the present invention that the composition and volume percent of the low temperature additive will be varied within the stated limits to meet the unique needs of the local motor fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other low temperature additives, such as vinyl acetate polymers, water scavengers, etc., may suffice.

The comprehensive fuel additive composition of the present invention is preferably made by carefully mixing the disclosed ingredients together, in any desired order. No significant or permanent chemical reactions among ingredients are expected to take place. Care should be taken to avoid contact with the fuel additive composition, which is toxic. Care should be taken to prevent accidental ignition of the fuel additive composition, which is highly flammable.

The fuel additive system of the current invention may also comprise transportation fuel containing the comprehensive fuel additive of the instant invention. The comprehensive fuel additive may be added to transportation fuel after refining, during storage, or in the consumer's gas tank. Preferably, the comprehensive fuel additive is added to transportation fuel that is in a fuel storage tank, prior to sale or distribution to individual consumers. At this stage, it is simple and efficient to add the comprehensive fuel additive by pouring a chosen amount of fuel additive into the fuel storage tank and mixing the fuel and additive. Preferably, the comprehensive fuel additive is mixed in a ratio of 1000 gallons of fuel to 1 gallon of comprehensive fuel additive. Upon reading this specification, those of ordinary skill in this art will understand that under appropriate circumstances, such as cost, availability, convenience,

and the precise needs of the fuel to be treated, etc., other treatment ratios, such as 10:1, 500:1, 5,000:1, 10,000:1, 372:1, etc., may suffice.

Diesel fuel additives will now be discussed. Cetane is a measure of the combustion speed of diesel. Vehicles are designed to operate on fuel with a particular cetane (such as, for example, 42, 45, or 47) and refineries refine multiple diesel fuels with the required cetane levels. Cetane can be adjusted by varying the hydrocarbon composition of the base fuel, by oxygenating the fuel, or by adding additives. Low quality fuels may have low cetane due to insufficient control of the hydrocarbon content of the base fuel or the lack of availability of cetane boosting (combustion boosting) additives. Using fuel with the wrong cetane for the vehicle can result in stalling, knocking, inefficient combustion, and low fuel economy. Adding oxygenates to diesel boosts the diesel's cetane level and reduces atmospheric pollution associated with diesel vehicle emissions by making more oxygen available for combustion. Examples of fuel oxygenates are: methyl tert-butyl ether (MTBE), ethyl tert-butyl ether (ETBE), tert-amyl methyl ether (TAME), diisopropyl ether (DIPE), tert-amyl alcohol (TAA), tert-butyl alcohol (TBA), methanol, and ethanol. Other cetane boosters function by adjusting the hydrocarbon content of the fuel by providing especially volatile, hot-burning hydrocarbons to the fuel. Such cetane boosting hydrocarbons include cumene, toluene, benzene, naptha, xylene, isopropyl alcohol, and tertiary butyl alcohol. These volatile compounds also have the advantage of serving as fuel injector cleaners before combusting. A comprehensive diesel fuel additive of the present invention comprises at least one of the following cetane boosters: 2-ethylhexyl nitrate, cumene, n-propylbenzene, toluene, xylene, benzene, nitromethane, nitroethane, propylene oxide, octyl nitrate, naptha, methyl tert-butyl ether (MTBE), ethyl tert-butyl ether (ETBE), tert-amyl methyl ether (TAME), diisopropyl ether (DIPE), tert-amyl alcohol (TAA), tert-butyl alcohol (TBA), methanol, ethanol, isopropyl alcohol, tert-amyl alcohol, alcohols, and/or ethers. The cetane boosters may comprise about 20 to 70% by volume of the diesel fuel additive. Preferably, the cetane boosters may comprise about 30 to 60% by volume of the diesel fuel additive. Most preferably, the cetane boosters may comprise about 40 to 50% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel additive comprises about 30% 2-ethylhexyl nitrate, by volume. A comprehensive diesel fuel additive of the present invention also comprises the cetane booster 2-ethylhexyl alcohol. 2-Ethylhexyl alcohol may comprise about 0.5 to 5.5% by volume of the diesel fuel additive. Preferably, 2-ethylhexyl alcohol may comprise about 1 to 5% by volume of the diesel fuel additive. Most preferably, 2-ethylhexyl alcohol may comprise about 1 to 3% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel additive is

about 2% 2-ethylhexyl alcohol, by volume. It is an object and feature of the present invention that the composition and volume percent of the cetane booster will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other cetane enhancers (combustion boosters) may suffice.

Combustion modifiers function by chemically modifying the combustion of the fuel to slow burning, speed up burning, or enhance complete combustion. Such combustion modifiers include ferrocene and methylcyclopentadienyl manganese tricarbonyl, platinum, cerium, ALKEN EVEN FLO 910™ or HITEC 3023™. A comprehensive diesel fuel additive of the present invention comprises at least one of the following combustion modifiers: ferrocene, platinum, cerium, manganese, methylcyclopentadienyl manganese tricarbonyl, HITEC 3023™, ALKEN EVEN FLO 910™, and nitromethane. The combustion modifier nitromethane may comprise about 0.5 to 3% of the diesel fuel additive. Preferably, the combustion modifier nitromethane may comprise about 1.0 to 2% of the diesel fuel additive. More preferably, the combustion modifier nitromethane may comprise about 1.5 to 1.75% of the diesel fuel additive. The combustion modifier ALKEN EVEN FLO 910™ may comprise about 0.5 to 6% of the diesel fuel additive. Preferably, the combustion modifier ALKEN EVEN FLO 910™ may comprise about 1 to 5% of the diesel fuel additive. More preferably, the combustion modifier ALKEN EVEN FLO 910™ may comprise about 3 to 4% of the diesel fuel additive. The combustion modifier HITEC 3023™ may comprise about 2 to 10% of the diesel fuel additive. Preferably, the combustion modifier HITEC 3023™ may comprise about 3 to 9% of the diesel fuel additive. More preferably, the combustion modifier HITEC 3023™ may comprise about 5 to 6% of the diesel fuel additive.

The combustion modifiers platinum and/or cerium may comprise about 1 to 15 ppm of the diesel fuel additive. Preferably, the combustion modifiers platinum and/or cerium may comprise about 2 to 12 ppm of the diesel fuel additive. More preferably, the combustion modifiers platinum and/or cerium may comprise about 4 to 10 ppm of the diesel fuel additive. The combustion modifiers manganese and/or methylcyclopentadienyl manganese tricarbonyl may comprise about 4 to 45 ppm of the diesel fuel additive. Preferably, the combustion modifiers manganese and/or methylcyclopentadienyl manganese tricarbonyl may comprise about 10 to 40 ppm of the diesel fuel additive. More preferably, the combustion modifiers

manganese and/or methylcyclopentadienyl manganese tricarbonyl may comprise about 20 to 30 ppm of the diesel fuel additive.

The combustion modifier ferrocene (dicyclopentadienyl iron) may comprise about 0.5 to 6%, of a 10% ferrocene liquid concentrate, of the diesel fuel additive. Preferably, the combustion modifier ferrocene may comprise about 1 to 5 volume percent, of a 10% ferrocene liquid concentrate, of the diesel fuel additive. More preferably, the combustion modifier ferrocene may comprise about 2 to 4 volume percent, of a 10% ferrocene liquid concentrate, of the diesel fuel additive. Most preferably, the combustion modifier may comprise about 3% by volume, of a 10% ferrocene liquid concentrate, of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel additive comprises about 3% by volume of a 10% ferrocene liquid concentrate, to catalyze combustion. It is a feature of the present invention that the composition and volume percent of the combustion modifier will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other combustion modifiers, such as ferrocene in other forms than in a liquid concentrate, nitrates, chemical compounds of manganese, platinum, or cerium, or other metals, may suffice.

Corrosion inhibitors typically coat the internal surfaces of the engine and fuel system to prevent water, ethanol, and other corrosive substances from contacting the fuel system surfaces. There are several types of corrosion inhibitors. Polar compounds wet the metal surface preferentially, protecting it with a film of oil. Other compounds may absorb water by incorporating it in a water-in-oil emulsion so that only the oil touches the metal surface. Another type of corrosion inhibitor combines chemically with the metal to present a non-reactive surface. Typical corrosion inhibitors used in vehicles include organic molecules, azoles, amines, nitrites, phosphates, molybdates, phosphonates, and silicates. A comprehensive diesel fuel additive of the present invention comprises at least one of the following corrosion inhibitors: azoles, amines, nitrites, phosphates, molybdates, phosphonates, silicates, DCI series products, DCI 4A ™, DCI 6A ™, DCI 11 ™, DCI 28 ™, DCI 30 ™, HITEC 580 ™, BIOBOR JF™, and ONDEO-NALCO 5403 ™. Preferably, the corrosion inhibitors disclosed above are present as about 0.1 to 5.1% by volume of the diesel fuel additive. More preferably, the corrosion inhibitors disclosed above are present as about 0.25 to 1% by volume of the diesel fuel additive. Most preferably, the corrosion inhibitors disclosed above are present as about 0.5 to 0.75% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the

diesel fuel additive comprises about 0.75% DCI 4A™, by volume. It is an object and feature of the present invention that the composition and volume percent of the corrosion inhibitor will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other corrosion inhibitors, such as the components of the above mentioned trademarked corrosion inhibitors in other forms or from other sources, organic molecules, ALKEN EVEN FLO 910™, etc., may suffice.

Water in diesel fuel can damage fuel injectors by explosively vaporizing at the tip of hot fuel injectors. For water-contaminated fuel, additives may be used to demulsify the water and incorporate the water harmlessly into the fuel, or additives may be used to force water out of solution and drop to the bottom of the storage tank. Other additives, such as alcohols, chemically bind with water to move it harmlessly through the fuel system. A comprehensive diesel fuel additive of the present invention comprises at least one of the following water managers: DMA 451™, DDA-4500™, HITEC 6471™, HITEC 6423™, ALKEN EVEN FLO 910™, water scavengers, alcohols, and 2-butoxyethanol. Preferably, the water managers disclosed above are present as about 4 to 20% by volume of the diesel fuel additive. More preferably, the water managers disclosed above are present as about 5 to 15% by volume of the diesel fuel additive. Most preferably, the water managers disclosed above are present as about 5 to 10% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel additive comprises about 5% DMA 451™, by volume. It is an object and feature of the present invention that the composition and volume percent of the water managers will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other water managers, such as the components of the above mentioned trademarked water demulsifiers in other forms or from other sources, surfactants, dispersants, alcohols, ethers, etc., may suffice.

Fuel detergents clean fuel injectors and valves of carbon deposits, improving engine efficiency. Detergents help control varnish, ring zone deposits, and rust by keeping insoluble particles in colloidal suspension and in some cases, by neutralizing acids. Detergents are commonly metallic (commonly barium, calcium, or magnesium) compounds, such as sulfonates, phosphonates, thiophosphonates, phenates, or salicylates. Metallic detergents create

a metallic ash byproduct after combustion. Another class of fuel system detergent are amines, such as, for example, polyalkyl amines, polyether amines, polyalkyl succinimides, and polyalkylaminophenols. Amine detergents have the advantage of not producing metallic ash byproducts. BASF's Polyisobutyleneamine (PIBA), and Polyetheramine (PEA) are two commercially available examples. A comprehensive diesel fuel additive of the present invention comprises at least one of the following detergents: DMA series products, DMA 451™, DMA 558™, DMA 559™, DMA 560™, DMA 561™, DMA 562™, DMA 563™, DMA 564™, sulfonates, phosphonates, thiophosphonates, phenates, salicylates, amines, polyalkyl amines, polyether amines, polyalkyl succinimides, polyalkylaminophenols, Polyisobutyleneamine (PIBA), and/or Polyetheramine (PEA). Preferably, the detergents disclosed above are present as about 4 to 20% by volume of the diesel fuel additive. More preferably, the detergents disclosed above are present as about 5 to 15% by volume of the diesel fuel additive. Most preferably, the detergents disclosed above are present as about 8 to 10% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the detergent component of the diesel fuel additive comprises about 10% DMA 451™, by volume. Preferably, a comprehensive fuel additive of the present invention also comprises other detergent(s): 2,4-pentanedione and/or 2,3-pentanedione. Preferably, 2,4-pentanedione and/or 2,3-pentanedione are present as about 4 to 20% by volume of the motor fuel additive. More preferably, 2,4-pentanedione and/or 2,3-pentanedione are present as about 5 to 15% by volume of the motor fuel additive. More preferably 2,4-pentanedione and/or 2,3-pentanedione are present as about 5 to 10.0% by volume of the motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive comprises about 10% 2,4-pentanedione, by volume. It is an object and feature of the present invention that the composition and volume percent of the detergent or solvent will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other fuel injector detergents, such as the components of the above mentioned trademarked detergents in other forms or from other sources, solvents, etc., may suffice.

Solvents are added to form a base in which the other constituents of the comprehensive diesel fuel additive may be dissolved. Also, solvents are effective and desired for dissolving and removing fuel system deposits. A comprehensive diesel fuel additive of the present invention comprises at least one of the following solvents: AROL 50™, HISOL 100™, xylene, toluene, benzene, naptha, n-propylbenzene, and/or cumene. Preferably, the solvents disclosed

above are present as about 20 to 60% by volume of the motor fuel additive. More preferably, the solvents disclosed above are present as about 20 to 50% by volume of the motor fuel additive. More preferably the solvents disclosed above are present as about 20 to 40% by volume of the comprehensive motor fuel additive. In the best mode, for typical circumstances, the motor fuel additive component to enhance solvent action comprises about 20% AROL 50™, by volume. A comprehensive diesel fuel additive of the present invention also comprises the solvent heavy aromatic naptha. Preferably, heavy aromatic naptha is present as about 1 to 15% by volume of the diesel motor fuel additive. More preferably, heavy aromatic naptha is present as about 2 to 10% by volume of the motor fuel additive. Most preferably, heavy aromatic naptha is present as about 2 to 5% by volume of the motor fuel additive. In the best mode, for typical circumstances, the diesel motor fuel additive comprises about 2.5% heavy aromatic naptha, by volume.

Diesel fuel stabilizers are added to prevent fuel oxidation and deterioration during fuel storage, typically by terminating free radicals and thereby preventing oxidation and hydrocarbon chain polymerization. Preventing oxidation prevents hydrocarbons from linking together into random insoluble films that clog filters and fuel injectors. A highly oxidized fuel may be so thick and lumpy that it is not pumpable or usable. Typical fuel stabilizers include alkylated phenols and diamines. A comprehensive diesel fuel additive component of the present invention comprises at least one of the following fuel stabilizers: DMA 558™, AO series products, AO 22™, AO 24™, AO 29™, AO 30™, AO 31™, AO 32™, AO 36™, AO 36D™, AO 37™, AO 37D™, 2,3-pentanedione, 2,4-pentanedione, amines, dispersants, and/or surfactants. Preferably, the fuel stabilizers disclosed above are present as about 4 to 15% by volume of the diesel fuel additive. More preferably, the fuel stabilizers disclosed above are present as about 5 to 10% by volume of the diesel fuel additive. Most preferably, the fuel stabilizers disclosed above are present as about 5 to 7% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel stabilizer additive component comprises about 5% DMA 558™, by volume. It is an object and feature of the present invention that the composition and volume percent of the fuel stabilizer will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other fuel stabilizers, such as the components of the above mentioned trademarked stabilizers in other forms or from other sources, detergents, etc., may suffice.

As mentioned, biocides are used to kill microbes that eat hydrocarbons. Microbe-contaminated diesel fuels have a bad smell and contain sticky strands of fungus and bacteria that clog fuel filters. Common fuel-contaminating microbes include cladosporium resinae fungus, as well as bacteria, yeast and other fungi. Microbes are most able to attack water-contaminated fuels. Some examples of diesel fuel biocides include thiazoles, thiocyanates, isothiazolins, cyanobutane, dithiocarbamate, thione, and bromo-compounds. Surfactants and water-scavengers are also useful for preventing biocontamination. A comprehensive diesel fuel additive of the present invention comprises at least one of the following biocides: 1,2,4-trimethylbenzene, T9312™, T9360™, 1,2,4-trimethylbenzene, KATHON 886™, BIOBOR JF™, thiazoles, thiocyanates, isothiazolins, cyanobutane, dithiocarbamate, thione, and bromo-compounds, surfactants, water-scavengers, and/or ONDEO-NALCO 303MC™. Preferably, the biocides disclosed above are present as about 0.05 to 5% by volume of the diesel fuel additive. More preferably, the biocides disclosed above are present as about 0.1 to 2% by volume of the diesel fuel additive. Most preferably, the biocides disclosed above are present as about 0.5 to 1% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel additive comprises about 1% T9312™, by volume. It is an object and feature of the present invention that the composition and volume percent of the biocide will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other biocides, such as the components of the above mentioned trademarked stabilizers in other forms or from other sources, detergents, cyanides, etc., may suffice.

A diesel fuel system lubricant helps prevent wear damage in areas of the engine that are not served by the engine oil, such as, for example, the fuel injectors, fuel pump, valves, and upper combustion chambers. Fuel system lubricants are typically elements, such as sulfur, lead, or molybdenum; alternatively, oils, polyalphaolefins, lubricants, or other organic molecules may be used to provide a lubricating film between metal surfaces. A comprehensive diesel fuel additive of the present invention comprises at least one of the following fuel system lubricants: AO series products, AO 22™, AO 24™, AO 29™, AO 30™, AO 31™, AO 32™, AO 36™, AO 36D™, AO 37™, AO 37D™, DCI series products, DCI 4A ™, DCI 6A ™, DCI 11 ™, DCI 28 ™, and DCI 30 ™, HITEC 580™, ONDEO-NALCO 5403™, OLI 5015™, OLI 5000 series products, OLI 9000 series products, oils, polyalphaolefins, and/or sulfur. Preferably, the fuel system lubricants disclosed above are present as about 1 to 3% by volume

of the diesel fuel additive. More preferably, the fuel system lubricants disclosed above are present as about 1.2 to 2.5% by volume of the diesel fuel additive. Most preferably, the fuel system lubricants disclosed above are present as about 1.5 to 2% by volume of the diesel fuel additive. In the best mode, for typical circumstances, the diesel fuel additive comprises about 2% OLI 5015™, by volume. It is an object and feature of the present invention that the composition and volume percent of the fuel system lubricant will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Upon reading this specification, those of ordinary skill in this art will now understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other fuel system lubricants, such as the components of the above mentioned trademarked stabilizers in other forms or from other sources, molybdenum, lead, other metals, etc., may suffice.

A low temperature additive keeps fuel liquid and flowing by preventing the chemical components of diesel fuel from forming crystals and solidifying at low temperatures. Some low temperature additives prevent crystal formation. Other low temperature additives, such as, for example, polymers, methacrylates, and wax modifiers, modify crystal growth to encourage the growth of linear or tiny crystals that do not clog fuel filters. Still other low temperature additives, such as, for example, methanol, dissolve wax crystals or prevent water ice from forming. Low temperature additives are often needed in cold climates, but are rarely used in tropical climates. A comprehensive diesel fuel additive of the present invention comprises at least one of the following low temperature additives: methanol, n-propanol, 2-butoxyethanol, isopropanol, polyalkyl methacrylate, polystyrene methacrylate, methacrylates, polymers, dispersants, wax modifiers, and/or alcohols. Preferably, the low temperature additives disclosed above are present as about 1 to 15% by volume of the diesel fuel additive. More preferably, the low temperature additives disclosed above are present as about 2 to 10% by volume of the diesel fuel additive. Most preferably, the low temperature additives disclosed above are present as about 5 to 6% by volume of the diesel fuel additive. A comprehensive diesel fuel additive according to the present invention may also comprise vinyl acetate polymer low temperature additives. Preferably, the vinyl acetate polymer low temperature additives disclosed above are present as about 10 to 40% by volume of the diesel fuel additive. More preferably, the vinyl acetate polymer low temperature additives disclosed above are present as about 20 to 35% by volume of the diesel fuel additive. Most preferably, the vinyl acetate polymer low temperature additives disclosed above are present as about 20 to 25% by volume of the diesel fuel additive. In the best mode, under appropriate circumstances, when needed,

the diesel fuel additive is about 20% vinyl acetate polymer, by volume. It is an object and feature of the present invention that the composition and volume percent of the low temperature additive will be varied within the stated limits to meet the unique needs of the local diesel fuel, climate, auto fleet, pollution composition, etc., of the customer. Many customers, in warm climates, will not need low temperature additives at all. Upon reading this specification, those of ordinary skill in this art will understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other low temperature additives, such as polymers, dispersants, wax modifiers, etc., may suffice.

The comprehensive diesel fuel additive composition of the present invention is preferably made by carefully mixing the disclosed ingredients together, in any desired order. No significant or permanent chemical reactions are expected to take place. Care should be taken to avoid contact with the composition, which is toxic. Care should be taken to prevent accidental ignition of the composition, which is highly flammable.

The comprehensive diesel fuel additive system of the current invention may also comprise diesel fuel containing the comprehensive fuel additive of the instant invention. The comprehensive diesel fuel additive may be added to diesel fuel after refining, during storage, or in the consumer's gas tank. Preferably, the comprehensive diesel fuel additive is added to diesel fuel that is in a fuel storage tank, prior to sale or distribution to individual consumers. At this stage, it is simple and efficient to add the comprehensive diesel fuel additive by pouring a chosen amount of diesel fuel additive into the diesel storage tank and mixing the diesel and additive. Preferably, the comprehensive diesel fuel additive is mixed in a ratio of about 1000 gallons of fuel to about 1 gallon of comprehensive diesel fuel additive. Upon reading this specification, those of ordinary skill in this art will understand that, under appropriate circumstances, such as cost, availability, convenience, and the precise needs of the fuel to be treated, etc., other treatment ratios, such as 10:1, 500:1, 5,000:1, 10,000:1, 372:1, etc., may suffice. After the comprehensive fuel additive has been prepared, it is delivered to the customer. Because all of the additive functions are contained in a single convenient formula, ordering, shipping, and storage are all simplified and facilitated. The comprehensive fuel additive is then added to the fuel to be treated.

FIG. 33 shows an illustration of comprehensive fuel additive **100** being poured into transportation fuel **333** in fuel storage tank **331** from container **330** and being mixed with motorized rotating mixer **332**. The comprehensive fuel additive **100** is fully soluble in transportation fuels and has a density of 0.904 at 60 degrees Fahrenheit, permitting easy mixing into transportation fuel **333**. Upon reading this specification, those of ordinary skill in this art

will now understand that, under appropriate circumstances, such as available storage facilities, transportation facilities, and refining facilities, etc., other locations of adding the comprehensive additive, such as immediately after refining, in a fuel tanker, and in the consumer's gas tank, may suffice. Upon reading this specification, those of ordinary skill in this art will understand that, under appropriate circumstances, such as available storage facilities, transportation facilities, and refining facilities, etc., other means of mixing the comprehensive fuel additive with transportation fuels, such as manual mixing, unaided dispersion, and fuel recirculation, may suffice. Preferably, the comprehensive fuel additive is formulated to provide ideal results when added to transportation fuel at a ratio of 1000 parts comprehensive fuel additive to 1,000,000 parts fuel (1000 parts per million.) For example, the comprehensive fuel additive could be formulated such that 1 gallon of the comprehensive fuel additive is added to 1000 gallons of diesel fuel in storage. This ratio is convenient to manufacture, ship, measure, and add to fuel. Upon reading this specification, those of ordinary skill in this art will understand that under appropriate circumstances, such as storage tank size, shipping method, local units of measure, etc., other comprehensive fuel additive ratios, such as 1 to 10, 1 to 100, 1 to 10,000, or 1 to 456, may suffice.

The following charts of formulations of the comprehensive fuel additive formula are provided as enabling examples. Total percentages over 100% are caused by chemicals being used for two purposes at the same time. For example, in the first example chart, 2.0 percent DCI 6A™ is counted once as a corrosion inhibitor and again separately as a fuel lubricant, but only one 2.0 percent dose of DCI6A™ is actually added to the comprehensive fuel additive formula.

For Gasoline, with low temperature additive, best mode	Volume %	Chemical
Octane Booster	3.0	cumene
Combustion Catalyst	2.0	Ferrocene
Corrosion Inhibitor	2.0	DCI 6A
Water remover	3.0	2-butoxyethanol
Detergent	20.0	DMA 558™
	6.0	2,4 Pentanedione
Solvents	50.0	Xylene
	2.0	n-propylbenzene
Fuel Stabilizer	2.0	AO 22™
Biocide	4.0	1,2,4-trimethylbenzene
Fuel Lubricant	2.0	DCI 6A
Low temperature additive	6.0	methanol

	102.0	TOTAL

Gasoline, no low temperature additive, best mode	Volume %	Chemical
Octane Booster	3.0	cumene
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	2.0	DCI 6A
Water remover	3.0	2-butoxyethanol
Detergent	20.0	DMA 558™
	6.0	2,4 Pentanedione
Solvents	56.0	Xylene
	2.0	n-propylbenzene
Fuel Stabilizer	2.0	AO 22™
Biocide	4.0	1,2,4-trimethylbenzene
Fuel Lubricant	2.0	DCI 6A
	102.0	TOTAL

For Gasoline, no low temperature additive, alternate chemicals	Volume %	Chemical
Octane Booster	4.0	MTBE
Combustion Modifier	10 ppm	Platinum
Corrosion Inhibitor	2.0	HITEC 580™
Water remover	3.0	methanol
Detergent	20.0	Polyetheramine (PEA)
	6.0	2,3 Pentanedione
Solvents	55.0	toluene
	2.0	n-propylbenzene
Fuel Stabilizer	2.0	2,4 pentanedione
Biocide	4.0	ONDEO-NALCO 303MC™
Fuel Lubricant	2.0	polyalphaolefins
	100.0	TOTAL

For Gasoline, high solvent	Volume %	Chemical
Octane Booster	3.3	cumene
Combustion Modifier	0.5	Ferrocene
Corrosion Inhibitor	0.1	DCI 6A

Water remover	1.0	2-butoxyethanol
Detergent	10.0	DMA 558™
	4.0	2,4 Pentanedione
Solvents	80.0	Xylene
	0.5	n-propylbenzene
Fuel Stabilizer	0.1	AO 22™
Biocide	0.5	1,2,4-trimethylbenzene
Fuel Lubricant	0.1	DCI 6A
Low temperature additive	0.0	methanol
	100.1	TOTAL

For Gasoline, no low temperature additive, low solvent	Volume %	Chemical
Octane Booster	5.5	cumene
Combustion Modifier	6.0	Ferrocene
Corrosion Inhibitor	5.1	DCI 6A
Water remover	10.0	2-butoxyethanol
Detergent	20.0	DMA 558™
	6.0	2,4 Pentanedione
Solvents	40.0	Xylene
	0.5	n-propylbenzene
Fuel Stabilizer	2.9	AO 22™
Biocide	4.0	1,2,4-trimethylbenzene
Fuel Lubricant	5.1	DCI 6A
Low temperature additive	0.0	methanol
	105.1	TOTAL

For Gasoline, no low temperature additive, high biocontamination	Volume %	Chemical
Octane Booster	3.0	cumene
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	2.0	DCI 6A
Water remover	10.0	ethanol
Detergent	20.0	DMA 558™
	6.0	2,4 Pentanedione
Solvents	40.0	Xylene
	1.0	n-propylbenzene
Fuel Stabilizer	4.0	AO 22™
Biocide	10.0	1,2,4-trimethylbenzene

	2.0	BIOBOR JF™
Fuel Lubricant	2.0	DCI 6A
Low temperature additive	0.0	methanol
	102.0	TOTAL

For Gasoline, alternates 1	Volume %	Chemical
Octane Booster	2.0	cumene
Combustion Modifier	1.0	Ferrocene
Corrosion Inhibitor	1.0	DCI 6A
Water remover	10.0	ethers
Detergent	20.0	DMA 558™
	6.0	2,4 Pentanedione
Solvents	50.0	Xylene
	2.0	n-propylbenzene
Fuel Stabilizer	2.0	AO 22™
Biocide	2.0	cyanobutane
	1.0	BIOBOR JF™
Fuel Lubricant	1.0	AO 22™
Low temperature additive	2.0	methanol
	100.0	TOTAL

For Gasoline, alternates 2	Volume %	Chemical
Octane Booster	5.5	tert-amyl alcohol
Combustion Modifier	2.0	HITEC 3023™
Corrosion Inhibitor	2.0	DCI 6A
Water remover	3.0	isopropyl alcohol
Detergent	20.0	barium thiophosphonate
	6.0	2,4 Pentanedione
Solvents	45.0	cumene
	5.5	n-propylbenzene
Fuel Stabilizer	5.1	dispersants
Biocide	3.9	1,2,4-trimethylbenzene
Fuel Lubricant	2.0	ONDEO-NALCO 5403
Low temperature additive	0.0	methanol
	100.0	TOTAL

For Gasoline, low octane	Volume %	Chemical
Octane Booster	5.5	nitromethane

Combustion Modifier	6.0	Ferrocene
	10 ppm	platinum
Corrosion Inhibitor	1.0	DCI 6A
Water remover	1.0	2-butoxyethanol
Detergent	10.0	DMA 558™
	4.0	2,4 Pentanedione
Solvents	70.0	Xylene
	1.0	n-propylbenzene
Fuel Stabilizer	0.5	AO 22™
Biocide	0.5	1,2,4-trimethylbenzene
Fuel Lubricant	0.5	DCI 11
Low temperature additive	0.0	methanol
	100.0	TOTAL

For Gasoline, high pollution	Volume %	Chemical
Octane Booster	5.0	ETBE
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	2.0	DCI 6A
Water remover	2.0	methanol
Detergent	35.0	DMA 558™
	10.0	2,4 Pentanedione
Solvents	40.0	Xylene
	1.0	n-propylbenzene
Fuel Stabilizer	1.0	AO 22™
Biocide	1.0	1,2,4-trimethylbenzene
Fuel Lubricant	1.0	lubricants
Low temperature additive	0.0	methanol
	100.0	TOTAL

For Gasoline, high water	Volume %	Chemical
Octane Booster	3.0	isopropyl alcohol
Combustion Modifier	3.0	HITEC 3023™
Corrosion Inhibitor	2.0	DCI 6A
Water remover	10.0	2-butoxyethanol
Detergent	20.0	DMA 558™
	5.0	2,4 Pentanedione
Solvents	45.0	naptha
	2.0	n-propylbenzene
Fuel Stabilizer	2.0	AO 22™

Biocide	7.0	1,2,4-trimethylbenzene
Fuel Lubricant	1.0	oils
Low temperature additive	0.0	methanol
	100.0	TOTAL

For Gasoline, high corrosion	Volume %	Chemical
Octane Booster	3.0	cumene
Combustion Modifier	2.9	Ferrocene
Corrosion Inhibitor	5.1	DCI 6A
Water remover	10.0	2-butoxyethanol
Detergent	20.0	calcium phenate
	6.0	2,4 Pentanedione
Solvents	43.0	Xylene
	2.0	n-propylbenzene
Fuel Stabilizer	2.0	AO 22™
Biocide	4.0	water-scavengers
Fuel Lubricant	2.0	polyalphaolefins
Low temperature additive	0.0	methanol
	100.0	TOTAL

For Diesel, with low temperature additive, best mode	Volume %	Chemical
Cetane Booster	30.0	2-ethylhexyl nitrate
	2.0	2-ethylhexyl alcohol
Combustion Catalyst	2.0	Ferrocene
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	5.0	DMA 451™
Detergent	5.0	DMA 451™
	10.0	2,4 Pentanedione
Solvents	20.0	AROL 50™
	2.5	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	1.0	T9312
Fuel Lubricant	2.0	OLI 5015™
Low temperature additive	20.0	Vinyl Acetate polymers
	105.0	Total

For Diesel, no low temperature additive, best mode	Volume %	Chemical
Cetane Booster	30.0	2-ethylhexyl nitrate
	2.0	2-ethylhexyl alcohol
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	5.0	DMA 451™
Detergent	5.0	DMA 451™
	10.0	2,4 Pentanedione
Solvents	40.0	AROL 50™
	2.5	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	1.0	T9312
Fuel Lubricant	2.0	OLI 5015™

For Diesel, no low temperature additive, alternate chemicals	Volume %	Chemical
Cetane Booster	30.0	ETBE
	2.0	2-ethylhexyl alcohol
Combustion Modifier	30 ppm	manganese
Corrosion Inhibitor	0.5	calcium phosphate
Water remover	5.0	HITEC 6471™
Detergent	5.0	Polyisobutyleneamine (PIBA)
	10.0	2,3 Pentanedione
Solvents	37.0	n-propylbenzene
	2.5	HA Naptha
Fuel Stabilizer	5.0	amines
Biocide	1.0	KATHON 886™
Fuel Lubricant	2.0	oils
	100.0	Total

For Diesel, no low temperature additive, high solvent	Volume %	Chemical
Cetane Booster	20.0	2-ethylhexyl nitrate
	0.5	2-ethylhexyl alcohol
Combustion Modifier	4 ppm	manganese
Corrosion Inhibitor	0.1	DCI 4A™

Water remover	5.0	DMA 451™
Detergent	5.0	DMA 451™
	4.0	2,4 Pentanedione
Solvents	60.0	AROL 50™
	5	HA Naptha
Fuel Stabilizer	4.0	DMA 558™
Biocide	0.4	T9312
Fuel Lubricant	1.0	OLI 5015™
	105.0	Total

For Diesel, no low temperature additive, low solvent	Volume %	Chemical
Cetane Booster	31.0	2-ethylhexyl nitrate
	5.0	2-ethylhexyl alcohol
Combustion Modifier	5.0	Ferrocene
Corrosion Inhibitor	5.0	DCI 4A™
Water remover	10.0	DMA 451™
Detergent	10.0	DMA 451™
	10.0	2,4 Pentanedione
Solvents	20.0	AROL 50™
	1	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	5.0	T9312
Fuel Lubricant	3.0	OLI 5015™
	110.0	Total

For Diesel, no low temperature additive, high biocontamination	Volume %	Chemical
Cetane Booster	20.0	2-ethylhexyl nitrate
	2.0	2-ethylhexyl alcohol
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	10.0	alcohols
Detergent	20.0	magnesium salycilate
	11.0	2,4 Pentanedione
Solvents	20.0	AROL 50™
	2.5	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	5.0	T9312

Fuel Lubricant	2.0	OLI 5015™
	100.0	Total

For Diesel, alternates 1	Volume %	Chemical
Cetane Booster	40.0	octyl nitrate
	2.0	2-ethylhexyl alcohol
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	5.0	DMA 451™
Detergent	5.0	DMA 451™
	11.0	2,4 Pentanedione
Solvents	25.0	naptha
	2.5	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	1.0	dithiocarbamate
Fuel Lubricant	1.0	sulfur
	100.0	Total

For Diesel, alternates 2	Volume %	Chemical
Cetane Booster	30.0	2-ethylhexyl nitrate
	2.0	2-ethylhexyl alcohol
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	5.0	DMA 451™
Detergent	10.0	polyalkyl succinimides
	10.0	2,4 Pentanedione
Solvents	20.0	toluene
	2.5	HA Naptha
Fuel Stabilizer	5.0	amines
Biocide	1.0	bromo-compounds
Fuel Lubricant	2.0	OHITEC 580™
Low temperature additive	10.0	alcohols
	100.0	Total

For Diesel, low cetane	Volume %	Chemical
Cetane Booster	55.0	2-ethylhexyl nitrate
	1.0	2-ethylhexyl alcohol
Combustion Modifier	5.0	Ferrocene

	3.0	Nitromethane
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	4.0	DMA 451™
Detergent	4.0	DMA 451™
	4.0	2,4 Pentanedione
Solvents	20.0	benzene
	1	HA Naptha
Fuel Stabilizer	4.0	DMA 558™
Biocide	1.0	T9312
Fuel Lubricant	1.5	OLI 5015™
	104.0	Total

For Diesel, high pollution	Volume %	Chemical
Cetane Booster	30.0	tert-amyl alcohol
	2.0	2-ethylhexyl alcohol
Combustion Modifier	2.0	Ferrocene
Corrosion Inhibitor	0.5	DCI 4A™
Water remover	5.0	DMA 451™
Detergent	20.0	DMA 560™
	10.0	2,4 Pentanedione
Solvents	20.0	AROL 50™
	2.5	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	1.0	T9312
Fuel Lubricant	2.0	OLI 5015™
	100.0	Total

For Diesel, high water	Volume %	Chemical
Cetane Booster	39.0	isopropyl alcohol
	3.0	2-ethylhexyl alcohol
Combustion Modifier	1.0	Ferrocene
Corrosion Inhibitor	1.0	DCI 4A™
Water remover	20.0	DMA 451™
Detergent	20.0	DMA 451™
	4.0	2,4 Pentanedione
Solvents	20.0	AROL 50™
	2	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	1.0	T9312

Fuel Lubricant	2.0	OLI 5015™
Low temperature additive	2.0	n-propanol
	120.0	Total

For Diesel, high corrosion	Volume %	Chemical
Cetane Booster	30.0	xylene
	1.0	2-ethylhexyl alcohol
Combustion Modifier	1.9	Ferrocene
Corrosion Inhibitor	5.1	DCI 4A™
Water remover	20.0	alcohols
Detergent	7.0	DMA 451™
	5.0	2,4 Pentanedione
Solvents	20.0	cumene
	1	HA Naptha
Fuel Stabilizer	5.0	DMA 558™
Biocide	1.0	T9312
Fuel Lubricant	3.0	polyalphaolefins
	100.0	Total

The following chart of chemical species and classes used to manufacture the comprehensive fuel additive is provided to enable each chemical species and chemical class.

Component	**Gasoline Use**	**Diesel Use**	**Chemical details**	**Example Source**
1,2,4-trimethylbenzene	Biocide	Biocide	$C6H3(CH3)3$, CAS # 95-63-6	
2,3-pentanedione	Detergent, Fuel stabilizer	Detergent, Fuel stabilizer	$C2H5COCOCH3$, CAS # 600-14-6	
2,4-pentanedione	Detergent, Fuel stabilizer	Detergent, Fuel stabilizer	$CH3COCH2COCH3$, CAS # 123-54-6	
2-butoxyethanol	Water manager, Low temperature additive	Water manager, Low temperature additive	$CH_3(CH_2)_3OCH_2CH_2OH$, CAS # 111-76-2	
2-ethylhexyl alcohol		Cetane booster	$CH_3(CH_2)_3CH(CH_2CH_3)CH_2OH$, CAS # 104-76-7	
2-ethylhexyl nitrate		Cetane booster	$C_8H_{17}ONO2$, CAS # 27247-96-7	
alcohols	Octane booster, Water manager, Low	Octane booster, Water manager, Low	generic chemical class, octane booster, water manager, and low	

	temperature additive	temperature additive	temperature additive alcohols commonly known in the art	
ALKEN EVEN FLO 910™		Combustion modifier, Water manager	Naphtha, CAS # 64742-88-7, 30-74% weight;Non-ionic surfactant, CAS # 9005-07-6, 5 - 25% weight; Aliphatic & cyclic amines, CAS # 61791-24-0, 5 - 30% weight	Alken-Murray Corporation
alkylated phenols	Fuel stabilizer		generic chemical class, alkylated phenol fuel stabilizers commonly known in the art	
amines	Corrosion inhibitor, Detergent, Fuel stabilizer	Corrosion inhibitor, Detergent, Fuel stabilizer	generic chemical class, amine corrosion inhibitors, detergents, and fuel stabilizers commonly known in the art	
AO 22™	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	N,N'-di-sec-butyl-p-phenylenediamine	Octel Starreon LLC
AO series	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	Fuel Antioxidants	Octel Starreon LLC
AO-24 Antioxidant	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	A 50% A.I., principally N,N'-di-sec-butyl-p-phenylenediamine, in a high flash solvent	Octel Starreon LLC
AO-29	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	2,6-di-tert-butyl-4-methylphenol	Octel Starreon LLC
AO-30	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	100% alkylated phenols, principally 2,4-dimethyl-6-tert-butylphenol (97% min.).	Octel Starreon LLC
AO-31	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	100% alkylated phenols, principally 2,4-dimethyl-6-tert-butylphenol (72% min.)	Octel Starreon LLC
AO-32	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	100% alkylated phenols, principally 2,4-dimethyl-6-tert-butylphenol (55% min.) and 2,6-di-tert-butyl-4-methyl phenol (15% min.).	Octel Starreon LLC
AO-36	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	100% alkylated phenols, principally	Octel Starreon LLC

			propylated and butylated phenols	
AO-37	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	100% alkylated phenols, principally 2,6-di-tert-butylphenol	Octel Starreon LLC
AO-37 Dilute	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	80% alkylated phenols, principally 2,6-di-tert-butylphenol	Octel Starreon LLC
AO-37/70	Fuel stabilizer, Fuel lubricant	Fuel stabilizer, Fuel lubricant	70% alkylated phenols, principally 2,6-di-tert-butylphenol	Octel Starreon LLC
AROL 50™		Solvent	Aromatic Petroleum Distillates	
azoles		Corrosion inhibitor	generic chemical class, azole corrosion inhibitors commonly known in the art	
benzene	Octane booster, Solvent	Cetane booster, Solvent	C6H6, CAS # 71-43-2	
BIOBOR JF™	Biocide, Corrosion inhibitor	Biocide, Corrosion inhibitor	Mixed Dioxaborinanes & Naphtha, CAS # 8063-89-6	Hammonds Fuel Additives
bromo-compounds	Biocide	Biocide	generic chemical class, biocide bromo-compounds commonly known in the art	
cerium	Combustion modifier	Combustion modifier	Element Ce, CAS # 7440-45-1	
cumene	Octane booster, Solvent	Cetane booster, Solvent	$C_6H_5CH(CH_3)_2$, CAS # 98-82-8	
cyanobutane	Biocide	Biocide	CH3CH2CH2CH2CN, CAS # 110-59-8	
DCI series	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant	proprietary multifunctional additive	Octel Starreon LLC
DCI 11 ™	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant	proprietary multifunctional additive	Octel Starreon LLC
DCI 28 ™	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant	proprietary multifunctional additive	Octel Starreon LLC
DCI 30 ™	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant	proprietary multifunctional additive	Octel Starreon LLC
DCI 4A ™	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant	proprietary multifunctional additive	Octel Starreon LLC

DCI 6A	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant	proprietary multifunctional additive	Octel Starreon LLC
DDA-4500™		Water manager	water manager	Octel Starreon LLC
diamines	Fuel stabilizer		generic chemical class, amine detergents commonly known in the art	
diisopropyl ether (DIPE)	Octane booster		$(CH_3)_2CHOCH(CH_3)_2$, CAS # 108-20-3	
dispersants	Fuel stabilizer, Low temperature additive	Fuel stabilizer, Low temperature additive	fuel dispersant additives commonly known in the art	
dithiocarbamate	Biocide	Biocide	generic chemical class, dithiocarbamate biocides commonly known in the art	
DMA series	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-451	Water manager, Detergent	Water manager, Detergent	fuel detergents	Octel Starreon LLC
DMA-496	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-498	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-537	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-537D	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-54	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-548	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-548D	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-549	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-551	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-552	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-553	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-554	Detergent	Detergent	fuel detergents	Octel Starreon LLC

DMA-555	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-558	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-559	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-560	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-561	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-562	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-563	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-564	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-570	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-571	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-572	Detergent	Detergent	fuel detergents	Octel Starreon LLC
DMA-600	Detergent	Detergent	fuel detergents	Octel Starreon LLC
ethanol	Octane booster, Water manager	Cetane booster, Water manager	CH_3CH_2OH / C_2H_6O, CAS # 64-17-5	
ethers	Octane booster, Water manager	Cetane booster, Water manager	generic chemical class, octane boosters and water managers commonly known in the art	
ethyl tert-butyl ether (ETBE)	Octane booster	Cetane booster	C6H14O, CAS # 637-92-3	
Ferrocene	Combustion modifier	Combustion modifier	C10H10Fe, CAS # 102-54-5	
Heavy aromatic naptha		Solvent	mixture, CAS # 64742-94-5	
HiSOL 100		Solvent	Aromatic Petroleum Distillates, CAS # 64742-94-5	
HITEC 580 ™		Corrosion inhibitor, Fuel lubricant		Ethyl Corporation, Ethyl Petroleum Additives, Inc.
HITEC 3023™		Combustion modifier		Ethyl Corporation,

HITEC 6423™		Water manager		Ethyl Petroleum Additives, Inc. Ethyl Corporation, Ethyl Petroleum Additives, Inc.
HITEC 6471™		Water manager		Ethyl Corporation, Ethyl Petroleum Additives, Inc.
isopropanol	Water manager, Low temperature additive, Octane booster	Water manager, Low temperature additive, Cetane booster	$CH_3CH(OH)CH_3$, CAS # 67-63-0	
isothiazolins	Biocide	Biocide	generic chemical class, isothiazolin biocides commonly known in the art	
KATHON 886™		Biocide	5-Chloro-2-methyl-4-isothiazolin-3-one, CAS # 26172-55-4, 10 - 12%; 2-Methyl-4-isothiazolin-3-one, CAS # 2682-20-4, 3 - 5%; Magnesium nitrate, CAS # 10377-60-3, 16 - 21%; Magnesium Chloride, CAS # 7786-30-3, 10% MAX; Water, CAS # 7732-18-5, 60 - 64%	Rohm and Haas Company
lubricants	Fuel lubricant	Fuel lubricant	upper combustion chamber and fuel injector lubricants commonly known in the art	
manganese	Combustion modifier	Combustion modifier	Element Mn, CAS # 7439-96-5	
methanol	Octane booster, Low temperature additive, Water	Cetane booster, Low temperature additive, Water	CH3OH, CAS # 67-56-1	

	manager	manager		
methyl tert-butyl ether (MTBE)	Octane booster	Cetane booster	$C5H12O$, CAS # 1634-04-4	
methylcyclopentadienyl manganese tricarbonyl	Combustion modifier	Combustion modifier	$CH3C5H4Mn(CO)3$, CAS # 12108-13-3	
molybdates		Corrosion inhibitor	generic chemical class, molybdate corrosion inhibitors commonly known in the art	
naptha	Octane booster, Solvent	Cetane booster, Solvent	generic chemical class, natha solvents, octane, and cetane boosters commonly known in the art	
nitrites		Corrosion inhibitor	generic chemical class, nitrite corrosion inhibitors commonly known in the art	
nitroethane	Octane booster	Cetane booster	$C2H5NO2$, CAS # 79-24-3	
nitromethane	Octane booster	Cetane booster, Combustion modifier	CH_3NO_2, CAS # 75-52-5	
n-propanol	Low temperature additive	Low temperature additive	$CH3(CH2)2$ OH, CAS # 71-23-8	
n-propylbenzene	Octane booster, Solvent	Cetane booster, Solvent	$C3H7C6H5$, CAS # 103-65-1	
octyl nitrate		Cetane booster	$C8H17NO3$, CAS # 27247-96-7	
oils	Fuel lubricant	Fuel lubricant	generic chemical class, lubricating oils commonly known in the art	
OLI 5015™		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
OLI-5000 series		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
OLI-5016 bc1		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
OLI-9000		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
OLI-9000 series		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
OLI-9050		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC

OLI-9055		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
OLI-9070		Fuel lubricant	Fuel Lubricant	Octel Starreon LLC
ONDEO-NALCO 303MC™	Biocide	Biocide	Biocide	Ondeo-Nalco
ONDEO-NALCO 5403 ™	Corrosion inhibitor, Fuel lubricant	Corrosion inhibitor, Fuel lubricant		Ondeo-Nalco
phenate		Detergent	generic chemical class, phenate detergents commonly known in the art	
phosphates		Corrosion inhibitor	generic chemical class, phosphate detergents commonly known in the art	
phosphonate		Corrosion inhibitor, Detergent	generic chemical class, phosphonate detergents commonly known in the art	
platinum	Combustion modifier	Combustion modifier	Element Pt, CAS # 7440-06-4	
polyalkyl amines	Detergent	Detergent	generic chemical class, polyalkyl amine detergents commonly known in the art	
polyalkyl methacrylate	Low temperature additive	Low temperature additive	C10H11, CAS # 9011-14-7	
polyalkyl succinimides	Detergent	Detergent	generic chemical class, polyalkyl succinimides commonly known in the art	
polyalkylaminophenols	Detergent	Detergent	generic chemical class, polyalkylaminophenol detergents commonly known in the art	
polyalphaolefins	Fuel lubricant	Fuel lubricant	generic chemical class, polyalphaolefin lubricants commonly known in the art	
polyether amines	Detergent	Detergent	generic chemical class, polyether amine detergents commonly known in the art	
Polyetheramine (PEA)	Detergent	Detergent		BASF

Polyisobutylenea mine (PIBA)	Detergent	Detergent		BASF
polymers	Low temperature additive	Low temperature additive	generic chemical class, polymer low temperature additives commonly known in the art	
polymethacrylate s	Low temperature additive	Low temperature additive	generic chemical class, polymethacrylate low temperature additives commonly known in the art	
polystyrene methacrylate	Low temperature additive	Low temperature additive	generic chemical class, polystyrene methacrylate low temperature additives commonly known in the art	
propylene oxide	Octane booster	Cetane booster	C3H6O, CAS # 75-56-9	
salicylates		Detergent	C7H6O3, CAS # 69-72-7	
silicates		Corrosion inhibitor	generic chemical class, corrosion inhibiting metal silicates commonly known in the art	
sulfonates	Detergent	Detergent	generic chemical class, metal sulfonate detergents commonly known in the art	
sulfur	Fuel lubricant	Fuel lubricant	element; CAS # 7704-34-9	
surfactants	Fuel stabilizer, Biocide	Fuel stabilizer, Biocide	substances that reduce the surface tension of fuel and water and thereby promote fuel/water emulsions	
T9312™	Biocide	Biocide		
T9360™	Biocide	Biocide		
tert-amyl alcohol (TAA)	Octane booster	Cetane booster	CH3CH2C(CH3)2OH, CAS # 00075-85-4	
tert-amyl methyl ether (TAME)	Octane booster	Cetane booster	$C_2H_5C(CH_3)_2OCH_3$, CAS # 994-05-8	
tert-butyl alcohol (TBA)	Octane booster	Cetane booster	$(CH_3)_3COH$, CAS # 75-65-0	

thiazoles	Biocide	Biocide	generic chemical class, thiazole biocides commonly known in the art
thiocyanates	Biocide	Biocide	generic chemical class, thiocyanate biocides commonly known in the art
thione	Biocide	Biocide	generic chemical class, thione biocides commonly known in the art
thiophosphonate		Detergent	generic chemical class, thiophosphonate detergents commonly known in the art
toluene	Octane booster, Solvent	Cetane booster, Solvent	C6H5CH3, CAS # 108-88-3
Vinyl acetate polymers		Low temperature additive	
water-scavengers	Water manager, Biocide	Water manager, Biocide	fuel/water emulsidiers or demulsifiers commonly known in the art
wax modifiers	Low temperature additive	Low temperature additive	Diesel wax modifiers commonly known in the art
Xylene	Octane booster, Solvent	Cetane booster, Solvent	A mixture of ortho, para and meta dimethylbenzene. C6H4(CH3)2, CAS # 1330-20-7

The following (making reference to many of the figures of this application) is a report on independent tests (performed and written by Edward R. Eaton, Amalgatech Laboratories, Inc.) completed on a preferred embodiment of the comprehensive fuel additive of the present invention (called the *Formula Plus*™ additives):

Technical Report, Formula Plus™ Gasoline and Diesel Fuel Technology

By Edward R. Eaton, Amalgatech

PRODUCT OBJECTIVES

In the course of their worldwide travels, the inventors experienced the increasing pollution that was becoming a concern in developing countries as their economies grew faster than local industry technologies' ability to prevent or clean up the emissions. Discussions with

many government officials demonstrated an unmet need for a fuel chemistry that would contribute to national goals that included reducing emissions, improving fuel efficiencies, and generally extending the life of vehicles and other equipment, all desirable objectives in developing economies. A search of global technologies uncovered interesting chemistries that might be successfully combined into a novel chemical technology that would offer very interesting benefits to a wide range of vehicles, climates, and local fuel chemistries. The objectives developed after the global review of available technologies included:

- Reduce emissions, in particular smoke, carbon monoxide, diesel particulates and diesel NOx.
- Appreciably improve fuel economy.
- Extend the life of fuel system components, conserving their ability to function efficiently.
- Improve vehicle performance ("drivability" and power).
- Provide cold-temperature fuel flow improvement in both conventionally refined and hydroprocessed diesel fuels.

Formula Plus conducted research using various novel combinations of technologies until the objectives were satisfied.

TEST METHODS

LABORATORY METHODS - Laboratory test methods were chosen from North American ASTM test methods, global OEM specifications, and published European standards. For convenience, the details of each test method will be included immediately before the results of each test are reported, below. These methods include engine dynamometer and chassis dynamometer approaches.

FIELD TEST METHODS – A field test method was developed to evaluate the benefit that the technology provides in actual operating vehicles.

HEAVY DIESEL TEST RESULTS

LABORATORY TESTS – The first group of tests that will be reported are controlled laboratory tests. These include both engine dynamometer and chassis dynamometer test methods.

Cummins Engine Company L-10 Injector Deposit 'Keep Clean' Test

The Cummins L-10 diesel engine is a six cylinder four-cycle American made diesel. Cummins developed an injector deposit test using this engine, because injector deposits severely degrade the operating characteristics of this (and other) engine. The test involves running the engine on a control #2 Caterpillar-specified diesel fuel to establish a baseline. The

engine's timing and fuel flow settings are adjusted to encourage deposit formation. Then several runs are performed with the test fuel and the degree to which injectors have been plugged by deposits are compared.

FIG. 1 illustrates that Formula Plus reduced the deposits by 67%.

Cummins Engine Company L-10 Injector Carboning 'Keep Clean' Test

The same Cummins L-10 diesel engine is used to test carbon deposit build-up on the injectors. The engine's timing and fuel flow settings are adjusted to encourage deposit formation. The degree to which the injector surfaces accumulate carbon is represented by demerits on a scale known as the CRC scale. This is a comparative scale, using photos of previous tests for rating purposes. Fewer demerits reflect cleaner injectors. This test was performed with both standard process (high sulfur) and hydroprocessed (low sulfur) control fuels. In the case of the standard fuel, *Formula Plus* reduced the carbon deposits by 60%, and in low sulfur fuel 53%.

FIG. 2 illustrates the data derived from the Cummins L-10 Engine 125 Carbon Test.

Cummins Engine Company L-10 Injector Carboning 'Clean Up' Test

The Cummins L-10 diesel engine is also used to test the ability of an additive to remove existing carbon deposit build-up on the injectors. The engine's timing and fuel flow settings are adjusted to encourage deposit formation, and the engine is run on the control fuel for 125 hours, The fuel is then treated with the additive, and run another 125 hours. The injectors are removed and inspected at 125, 160, 210 and 350 total hours. The degree to which the injector surfaces accumulate or lose carbon is recorded in "demerits". This test was performed with both standard process (high sulfur) and hydroprocessed (low sulfur) control fuels. In both fuels Formula Plus removed about 50% of the built-up carbon in 125 hours of operation.

FIG. 3 illustrates the data derived from the "Clean Up" test.

Cummins Engine Company L-10 Injector Comparison 'Clean Up' Test

Formula Plus were interested in knowing how the performance of their technology compared to respected products that were already in the marketplace. The laboratory nominated a highly successful premium diesel manufactured in the US by BP. This #2 diesel is considered by many to be the best and most accepted premium diesel fuel in the US. Therefore, it provided a good standard commercial product against which the performance of Formula Plus technology could be compared. The test selected for comparison was the Cummins L-10 Injector keep-clean test.

FIG. 4 illustrates the relative performance of the Formula Plus technology. The commercial premium diesel tested 37% better than the control, and Formula Plus tested 60% better than the control.

Cummins N-14 Engine Company Injector Erosion-Corrosion Test

One wear behavior experienced by heavy-duty diesel engines is injector erosion. Injector erosion results in more fuel entering the combustion chamber than is specified, resulting in over-fueling. Over fueling causes reduced fuel economy and increased emissions. The Cummins N-14 injector erosion tests measures the ability of a fuel chemistry to protect the injectors against this damaging wear behavior. In this test, the Formula Plus technology performed very well. The test was run two times, once on conventional and once on low sulfur fuel.

FIG. 5 illustrates the results of the injector erosion-corrosion tests. With conventional fuel, injector wear was bad enough to permit an increase in fuel flow of 7.14 % (average of the 6 injectors). On low sulfur fuel the increase was 6.00%. After adding the Formula Plus, standard fuel did not produce any increase in fuel flow (-0.02%) and the low sulfur fuel produced only 0.28% increase in fuel flow.

Corrosion Protection for Fuel System Components

The National Association of Corrosion Engineers (NACE) has a method (TM0172-93) used to determine the ability of fuel or lubricant chemistry to prevent corrosion on steel. The method involves a controlled exposure of a steel specimen in the fluid, and includes a rating system that uses grades A (no damage at all) to E (completely covered with rust).

FIG. 6 illustrates how the test results demonstrated the anti-corrosion capability of Formula Plus. The steel specimen (601) exposed to fuel is heavily corroded, while the steel specimen (602) exposed to fuel with Formula Plus has no visible corrosion.

TABLE 1: NACE TM0172-93 Test Results

Sample	Grade	%Corrosion
#2 Low Sulfur	E	97%
#2 Low Sulfur with Formula Plus	B++	<0.1%
#2 High Sulfur	E	98%
#2 High Sulfur with Formula Plus	B++	<0.1%
#2 LSD HFP	D	82%
#2 LSD HFP with Formula Plus	A	0 %

Corrosion Protection for Copper

The ASTM D130 test evaluates the ability of chemistry to protect copper. A polished copper strip is immersed in 34 ml of fuel for 3 hours at 100 degrees C. The strip is then rated on a scale of "1a" (best, no corrosion) to "4c" (strip is covered in corrosion). In this test, the base fuel and treated fuel both rated "1a", no corrosion to copper.

Fresh fuel burns far more efficiently than fuel that had chemically degraded over time. Fuel begins to degrade as soon as leaves the refinery.

FIG. 7 illustrates the effectiveness of the Formula Plus fuel stability additive. The test involves bubbling oxygen through fuel at 95 degrees C or 16 hours to accelerate the formation of gums and asphaltenes. 20-30 mg/l is typically considered an acceptable maximum degradation performance. Formula Plus treated fuel generated less than 10 mg/l. The engine manufacturer's association (EMA) specifies a performance of less then 15 mg/l.

EMISSIONS TESTING

Emissions tests were conducted at ETS Engine Testing Laboratory. The first test was conducted in a Cummins L-10 unit PT- injector equipped engine. The fuel was Cat 1K 0.4% sulfur fuel. The injectors for runs 1 and 3 came from a California fleet truck and had average deposit ratings of 30.8 and 23.4. Injectors for run 2 were new, but run on a standard depositing cycle with Cat 1K fuel to develop an average deposit rating of 24.4. The test was designed to run 125 hours on an alternating cycle of 15 seconds loaded and 15 seconds no load. A reference test sequence was performed on the ETS Transient Emissions Test Stand using the FTP Hot-Start Transient Emissions Test and FTP Smoke Test. The injectors are removed and rated. Then a 'stabilization phase' using the Cat 1 K fuel for a 21-hour clean-up cycle is performed. The FTP Hot-Start Transient Emissions Test and FTP Smoke Tests are repeated. The final phase involves two or four 21-hour cycles according to the 'clean up' protocol. The FTP Hot-Start Transient Emissions Test and FTP Smoke Tests are repeated a third time. The injectors are rated after the end of the cleanup cycle. Three runs were conducted, two 48 hour and one 84 hour cycles. Of course, emission measurements are also made. The emissions that are measured include

- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Nitrogen oxides (NOx)
- Particulate matter (PM)
- Smoke

In addition, this dynamometer test included measurements for fuel economy and power output.

FIG. 8 illustrates the results of the deposit cleanup performance test.

FIG. 9 shows the emissions improvements realized during the third (84) hour run, which are also presented in this table:

	HC	**CO**	**NOx**	**PM**	**Smoke**
% Improvement	**3**	**6**	**0**	**13**	**7**

In addition to the emissions measurements, the fuel economy and brake horsepower were also measured. The fuel economy was 1% better (without combustion modifier) and the power output improved 4%.

Separating water to prevent it from damaging fragile and expensive fuel system parts is accomplished by demulsification technology. ASTM D1094 measures the effectiveness of this technology. This test was performed with Formula Plus in commercial low sulfur diesel fuel (Table 2).

WATER MANAGEMENT

Table 2	5 min	10 min	15 min	20 min
LSD				
Interface	2 brown shred	2 brown shred	2 brown shred	2 brown shred
Separation	2 small drops	2 small drops	2 small drops	2 small drops
ΔVolume	-0.5 ml	-0.5 ml	0	0
LSD with FP				
Interface	3, 25% loose	3, 25% loose	2, 20% loose	2, 15% loose
Separation	3 haze	3 haze	3 haze	2 slight haze
ΔVolume	+0.5 ml	+0.5 ml	+0.5 ml	+0.5 ml

LIGHT DUTY DIESELTEST RESULTS

Light duty diesels account for 50% or more of passenger vehicles in many parts of the world. Diesel is often a less expensive fuel, and almost always provides a lower overall fuel cost. The testing that is conducted in light duty diesels is generally set by European specifications, and employs European cars and engines. In addition to tests for fuel economy,

system cleanliness and emissions optimization, fuel lubricity is also important (we note that in the USA lubricity requirements are specified in ASTMD 973).

FIG. 10 illustrates the results of a fuel stability test. Diesel fuel degrades with time to form asphaltenes and other varnish and/or tar-like heavy molecules. Stabilizer technology retards this process. A way of quantifying the effectiveness of the stabilizer is to prepare a treated and a control sample, then to age them in a laboratory oven for a week. After that period, the specimens are filtered, and the results are compared visually and by weight to demonstrate the effect of the stabilizer. In FIG. 10, the filter paper on the left (101) is the paper after filtering the treated specimen, while the paper on the right (102) is the control without stabilizer.

FIG. 11 reports the data from the Peugeot XUD9 fuel injector "keep clean" test. There are four injectors in this engine. The average flow restriction decreased from 87.8 to 78.3 (@ 0.1 mm Pintle Lift %).

FIG. 12 similarly illustrates the "clean up" behavior documented for Formula Plus in Peugeot specification testing.

FIG. 13 illustrates a damaged injector tip with carbon build-up

The next test was designed to demonstrate that the technology is effective with different makes of vehicles. It was repeated with four European automotive diesels and produced the following clean-up performance on the fuel injectors:

•Renault 2.1TD	29%
•Citroën BX 1.9D	55%
•Ford Orion 1.6D	76%
•Fiat Tipo 1.7D	56%

The test is a street test that simulates commuter driving in Europe. It is known as "The Commuter Traffic Road Test". It involves actually driving the vehicles in city streets and local highways for 2,000 km. The vehicles were driven 750 km, about 1 tank full of fuel, with standard low sulfur fuel in a 'dirty up' period. After the initial dirty up period, treated fuel was added to the tank and the vehicles were driven the 1,250 km remaining in the protocol. The injector performance was measured at 250 km intervals.

Tables 3, and FIGS. 14-17, show the results of the tests.

Table 3	Renault 21. TD	Citroen BX 1.9D	Ford Orion 1.6D	Fiat Tipo 1.7D
Volume, cm^3	2068	1905	1608	1697

Bore x Stroke, mm	86 x 89	83 x 88	80 x 80	82.6 x 79.2
Compression ratio	21.5:1	23.5:1	21.5:1	20.0:1
Max power, kW	65 @ 4250 rpm	51 @ 4600 rpm	40 @ 4800 rpm	42 @ 4600 rpm
Max Torque, Nm	181 @ 2000 rpm	120 @ 2000 rpm	95 @ 3000 rpm	98 @ 2900 rpm
Odometer Reading at End of Test, km	72779	80125	22768	170962

FIG. 14 illustrates the residual fuel injector flow in a Renault during the commuter traffic road test.

FIG. 15 illustrates the residual fuel injector flow in a Citroen during the commuter traffic road test.

FIG. 16 illustrates the residual fuel injector flow in a Ford during the commuter traffic road test.

FIG. 17 illustrates the residual fuel injector flow in a Fiat during the commuter traffic road test.

The data for the four European cars all reflected a capability of the chemistry to clean the injectors in a test of actual city operation.

Effect on Emissions

A chassis dynamometer test was conducted to evaluate the capability of Formula Plus technology to reduce diesel emissions in automotive diesels. An MVEG test cycle was run on four cars. The vehicles selected for this evaluation were:

•Audi A4 1.9 TDI

•Audi A6 2.5 TDI

•Renault Espace 2.1 TD

•MB C200D (oxycat)

The following graphs illustrate the degree of positive effect provided by Formula Plus in light duty diesel automobiles.

FIG. 18 illustrates Carbon Monoxide (CO) emissions in all four cars.

FIG. 19 illustrates hydrocarbon (HC) emissions in all four cars.

FIG. 20 illustrates Nitrogen Oxides (NOx) emissions in all four cars.

FIG. 21 illustrates particulates emissions in all four cars.

The light-duty diesel tests confirmed the results of the heavy-duty diesel experiments. The technology used in Formula Plus improves fuel economy and reduces tailpipe emissions.

GASOLINE ENGINE TESTING

FIG. 22 illustrates the results of testing per the industry standard ASTM D5500 test procedure, which is commonly used for the evaluation of intake valve deposit formation. This method uses a 1985 BMW 318i driven in a 10% city, 20% urban and 70% highway driving for 16,000 km. In this test, Formula Plus reduced the deposits 92% compared to the base fuel (Table 4).

FIG. 23 shows how treated fuel qualifies to California Air Resources Board (CARB) pollution control requirements. CARB specifies that the treated fuel cannot permit a deposit in excess of 50 mg per valve. Formula plus permitted only 19 mg, less than 40% of the strict maximum allowed.

Table 4: EPA 65th Percentile Fuel & EtOH

Parameter	*Actual*	*Requirement*
Base Fuel Olefins, %v/v	16.3	≥ 11.4
Base Fuel Aromatics, %v/v	33.0	≥ 31.1
Base Fuel Sulfur, ppm w/w	504	≥ 340
Base Fuel T90 degrees F	349	≥ 339
Base Fuel IVD mg/valve	**420.9**	≥ 290
Oxygenate, (EtOH) %v/v	10	≥ 10
Test with Formula Plus	**33.2**	

Table 5: CaRFG2 IVD Certification Fuel

Parameter	*Actual*	*Requirement*
Base Fuel Olefins, %v/v	8.1	≥ 8.0
Base Fuel Aromatics, %v/v	35.7	≥ 24.0
Base Fuel Sulfur, ppm w/w	124	≥ 64
Base Fuel T90 degrees F	290	≥ 290
Oxygenate, (EtOH) %v/v	10	≥ 8
Test with Formula Plus	**19**	< 50

Although the USA requires only require 'keep clean' performance, Formula Plus provides a more aggressive 'Clean Up' capability in gasoline. To measure the ability of Formula Plus' technology to clean up fouled gasoline injectors (and carburetors), the Ford 2.3

liter and General Motors 3.1 liter engines were selected. These are extremely high population engines in North America, and offer a good representation of typical engineering.

Table 5: CaRFG2 IVD Certification Fuel

Parameter	*Actual*	*Requirement*
Base Fuel Olefins, %v/v	8.1	≥ 8.0
Base Fuel Aromatics, %v/v	35.7	≥ 24.0
Base Fuel Sulfur, ppm w/w	124	≥ 64
Base Fuel T90 o F	290	≥ 290
Oxygenate, (EtOH) %v/v	10	≥ 8
Test with Formula Plus	**19**	< 50

The testing comprises two 96 hour cycles, the first of which is performed with unadditized fuel to allow for deposit formation. The fuel is then treated with Formula Plus for the second cycle. The test represents approximately 6600 total miles.

FIG. 24 shows that in the Ford engine Formula Plus produced a reduction of 14.7%, in the GM engine the improvement was 15.9%. These are both modern, computer controlled low emissions CARB-compliant engines. The Clean-up capability of the technology was also evaluated on a European and Japanese car. The BMW 318i and Toyota 1.6 l 4AFE engines were chosen to represent the engines manufactured in these locations.

Table 6: Fuel Used in BMW IVD Clean-Up Test

Parameter	*Actual*
Base Fuel Olefins, %v/v	14.6
Base Fuel Aromatics, %v/v	36
Base Fuel Sulfur, ppm w/w	280
Base Fuel T90 degrees F	350
IVD Control Dirty-Up, mg	**400**
Clean-Up with FP, mg	**125**

FIG. 25 shows that in the BMW test the IVD clean-up performance was 58.4%. FIG. 26 shows that in the Toyota test the IVD clean-up was 73.0%. Therefore all of the IVD tests produced positive clean-up capability data.

PORT FUEL INJECTOR TESTS

A series of port fuel injector tests was performed. The first test is performed with the Daimler Chrysler 2.2L engine. This is a Keep Clean test, using EPA 65th percentile fuel + 1-% EtOH (Table 8). Per ASTM 5598 performed with the DaimlerChrysler LeBaron 2.2L engine. Operating per ASTM D5598, The vehicle operates on a 15-minute drive cycle followed by a 45-minute soak. The cycle is carried out over 10,000 miles for injector cannot be more than 5.00% restricted after 10,000 miles.

FIG. 27a illustrates the results of the Formula Plus CARB DCA Certification test (CARB Certification Fuel) for the worst injector. Again, the worst injector after 10,000 miles may not experience more than a 5.00% flow restriction. The Formula Plus result was 0.47% (Table 8.)

Table 8: EPA 65th Percentile Fuel + EtOH

Parameter	*Actual*
Base Fuel Olefins, %v/v	15.0
Base Fuel Aromatics, %v/v	33.8
Base Fuel Sulfur, ppm w/w	380
Base Fuel T90 oF	339
Oxygenate (EtOH) v/v	10

Table 7: Fuel Used in Toyota IVD Clean-Up Test

Parameter	*Actual*
Base Fuel Olefins, %v/v	12.3
Base Fuel Aromatics, %v/v	32.4
Base Fuel Sulfur, ppm w/w	430
Base Fuel T90 degrees F	340
IVD Control Dirty-Up, mg	**220**
Clean-Up with FP, mg	**52**

FIG. 27b illustrates the results of the second PFI test, also performed with the DaimlerChrysler LeBaron 2.2L engine. Again operating per ASTM D5598, the vehicle operates on a 15-minute drive cycle followed by a 45-minute soak. The cycle is carried out over 10,000 miles for injector cannot be more than 5.00% restricted after 10,000 miles. The Formula Plus test CARB DCA Certification (CARB Certification Fuel). Again, the worst injector after 10,000 miles may not experience more than a 5.00% flow restriction. The D5598,

cars are run 10,000 miles, with ratings of the injector flow at 0, 1000, 3000, 7000 and 10,000 miles. Ratings reflect the fuel flow restriction as a % of the starting flow. CARB specifies that the worst result was 0.47% restriction. Formula Plus result was 0.45% (Table 9)

Table 9: CaRFG2 Certification Fuel

Parameter	*Actual*
Base Fuel Olefins, %v/v	8.1
Base Fuel Aromatics, %v/v	35.7
Base Fuel Sulfur, ppm w/w	124
Base Fuel T90 oF	290
Oxygenate (EtOH) v/v	9.5

The clean-up version of this test is performed using the CARB protocol. The drive cycle is the same as the 'Keep-Clean' test. In the test, an initial 'dirty up' period of 333 miles is completed to create a deposit on the injectors. The degree of fouling is measured. The fuel is changed to the test fuel, and run 1056 additional miles, with an interim inspection at 223 miles.

FIG. 28 shows that the Formula Plus additive cleaned 98% of the 'worst' injector, and an average of 99% overall after the 1056 miles of clean-up.

FIG. 29 shows the results of 'No Harm' testing on a BMW 318i performed to demonstrate that the Formula Plus technology does not degrade the performance of low-emissions low sulfur fuels required by the US EPA.

In all of these tests, Formula Plus greatly surpassed the clean air performance requirements published by US EPA and CARB.

COMBUSTION MODIFIERS

One of the most exciting and cost-effective technologies included in the Formula Plus package is that of combustion modifiers. These technologies accelerate the combustion process, providing a more complete burn of the fuel in each combustion event. The effectiveness of combustion modifier technologies has been proven in American and Canadian trial, and is now common in heavy-duty diesel and gasoline applications. The US EPA has approved combustion modifiers for use in the United States, a task that required extensive environmental evaluations spanning several years and at a cost of hundreds of thousands of dollars. Formula Plus provides these technologies, combined with other advanced chemistries to optimize fuel efficiency and emissions reductions, in a single balanced product. The diesel form of the technology involves a combination of cetane improver (4 points +/- 2) with an

organometallic molecule to provide optimum combustion. The gasoline version uses the organometallic in combination with an oxygenate.

FIG. 30 provides an overview of the catalytic cycle in fuel combustion.

FUEL ECONOMY TESTING

The effectiveness of fuel modifiers as fuel economy improvers has been demonstrated in actual user evaluations over long periods of time. The first set of data reported here was gathered from locomotive diesel engines in Canada in 1999 and 2000, during early product development. The test was controlled, with one set of locomotives running untreated fuel, and the other running the same fuel with Formula Plus combustion modifier technology.

FIG. 31 shows that in this test, the fuel economy improvement increased to as much as 11% compared to untreated fuel. After the test, the fuel economy of the treated engines returned to normal in three months.

FIG. 32 shows the results of a similar test in large 240 ton mine haul Caterpillar trucks that generated a fuel economy improvement of 12-16% in three trucks.

TESTING AROUND THE GLOBE

Fuel engineers are aware that fuels, vehicle types and operation duty cycles vary around the globe. To learn the effect of these variables on the ability of Formula Plus technology, several test evaluations have been completed.

Socialist Republic of Vietnam: Tests conducted in Vietnam on gasoline-powered vehicles generated the following results:

Vietnam Test per FP Test Protocol	Before/After	Improvement with Formula Plus
Carbon Monoxide, ppm	260/40	85%
Methane, ppm	68/14	80%
Fuel Economy, km / l	9.10/9.60	5.5%

Kingdom of Jordan: Tests conducted in Jordan on gasoline-powered vehicles generated the following results:

Jordan Test per FP Test Protocol	Before/After	Improvement with Formula Plus
Carbon Monoxide, ppm	573/114	80%
Methane, ppm	544/217	60%
Fuel Economy, km /	112/13	8.25%

United States: Tests conducted in Arizona on diesel and gasoline-powered vehicles generated the following results:

Arizona Test per FP Test Protocol	Before/After	Improvement with Formula Plus
Carbon Monoxide, ppm	45/16	22%
Methane, ppm	250/155	35%
Fuel Economy, mpg	25/27	6.15%

People's Republic of Bangladesh: Tests conducted in Bangladesh on diesel and gasoline- Powered vehicles generated the following results:

Bangladesh Test per FP Test Protocol	Before/After	Improvement with Formula Plus
Carbon Monoxide, ppm	565/110	80%
Methane, ppm	188/86	54%
Fuel Economy,	10.90/9.68	
diesel km / l		11%
gasoline km/l		8%

Overall Averages on all vehicles:

Overall Averages	Improvement with Formula Plus
Carbon Monoxide	67%
Methane	57%
Fuel Economy	9.73%

INTERPRETATION

After careful testing and analysis of the technology presented for testing, it is statistically sound that Formula Plus, Inc. has support in the form of empirical data to publish the following assertions:

1. The technology dramatically reduces tailpipe emissions compared to untreated gasoline (petrol) or #2 diesel fuel. In particular, the data is persuasive that carbon monoxide, methane and smoke and diesel particulates are reduced by an average of more than 50%. In spite of dramatic particulate reductions, the data do not reflect any increase in NOx emissions.

2. The data permit the assertion by arithmetic calculation, based on actual vehicle tests, that a fuel economy in excess of 9% has been documented, with range of results being 5% to 16%, depending upon the type of engine, type of fuel, and specific application.

3. Lubricity testing was not necessary because the lubricity enhancing component is well known to be and to the industry to be effective and is used in sufficient concentration in Formula Plus fuel additive to exceed the EMA/TMC premium diesel criteria, when used as directed. This is especially important to small diesel engines, but will extend the life and efficiency of all diesel engine fuel injection systems. (Note: This benefit is not applicable to or important for gasoline (petrol) engines.)

4. The product, used as directed, will increase power output as determined by dynamometer testing.

5. Used as directed, Formula Plus for Gasoline will increase RON Octane about 2 points. Formula Plus for Diesel will increase Cetane Number about 4 points (+/- 2).

6. Formula Plus will clean or keep clean gasoline and diesel fuel injection parts better than required by any published performance specifications.

7. Formula plus will protect all systems against corrosion.

8. Formula plus will prevent damage from suspended or emulsified water in fuel.

9. Formula Plus will improve drivability by restoring 'like new' performance to older vehicles with dirty fuel systems. This includes reducing engine knock, after-run, stalls, etc.

10. The product has been tested and found compatible with major ethyl vinyl acetate copolymer flow improvers, and may be effectively combined with them to offer cold temperature operability.

-End of Amalgatech Report-

As the comprehensive fuel additive of the current invention is particularly useful to users of low-quality fuels in underdeveloped countries, and as underdeveloped nations frequently refine their own transportation fuels under the aegis of a government-owned corporation, marketing and distributing the comprehensive fuel additive of the current invention requires novel steps and business methods. The comprehensive fuel additives of the present invention are principally marketed to political entities, such as, for example, countries, states, cities, towns, government-owned refineries or fuel storage depots, etc., in order to improve the quality of local transportation fuels. Potential political entity customers are chosen based on such factors as, for example, low local transportation fuel quality, high air pollution, low fuel economy, age of the local auto fleet, local climate, technological level of the local refinery, etc.

Once a potential customer is selected, a testing plan is devised to demonstrate the effectiveness of the comprehensive fuel additive. Appropriate government representatives, such as, for example, transportation ministers, presidents, energy company executives, etc., are then presented with the testing plan, and authorization to proceed is requested. Testing generally comprises daylong tests on local cars, first without and then with the use of the comprehensive fuel additive. Measurements of fuel efficiency, exhaust pollution, maximum speed, etc., are taken, and comparisons are made. Based upon these tests, changes may optionally be made in the comprehensive fuel additive to improve its effectiveness. For countries with multiple regions with distinctly different fuel additive needs, multiple tests resulting in multiple formulas may be performed. For example, the needs of coastal and high-altitude areas of Peru may be distinct from each other and require different comprehensive fuel additive formulas.

When the comprehensive fuel additive provides satisfactory results to the customer, an offer of sale is made. Sales are preferably multi-quarter contracts to deliver bulk comprehensive fuel additives to the customer. Preferably, quantities of comprehensive fuel additive sufficient to last for one quarter of a year are delivered on a quarterly basis. The comprehensive fuel additive may be delivered to any desired location, such as, for example, a refinery, fuel storage depot, gas station, military base, or warehouse. The comprehensive fuel additive may be shipped in any desired quantity, such as, for example, shipload, tanker, truckload, barrel, gallon, liter, or other such unit. Preferably, instructions for use are included. Instructions may be included with each shipment and/or on each unit.

Under appropriate circumstances, the comprehensive fuel additive may comprise low temperature additives none of the time, part of the time, or all of the time. For example, shipments to countries in Sub-Saharan Africa may never need low temperature additives, shipments to the Czech Republic may need low temperature additives only during the winter, and shipments to northern Siberia may always need low temperature additives. Seasonal variations of the other components of the comprehensive fuel additive are also possible. The contract of sale may be used to specify the particular formula to be shipped at which time of year.

FIG. 34 illustrates the steps of developing comprehensive fuel additives to sell to foreign customers to be used in foreign countries in order to ameliorate the deleterious effects of low-quality transportation fuels in the foreign country. First, fuel additive ingredients that are useful together are identified **340**. Then, an initial comprehensive fuel additive formula, as enabled by this application, is designed **341**, with a volume percent quantity assigned to each

ingredient. Next, the comprehensive fuel additive formula is tested **342**. An analysis **343** is then performed to determine if the results are satisfactory. If the results are not satisfactory, the formula is revised **344**, and it is tested **342** again. If the results are satisfactory, the formula may be presented **345** to a qualified **346** agent of a qualified **347** country.

After the initial presentation **345** of a demonstration testing plan, local testing **348** of the comprehensive fuel additive is performed. After local testing **348**, an analysis **349** of benefits is performed, to determine cost savings, pollution reduction, mileage increase, power increase, etc.

The qualified agent of the qualified country may then order **350** a trial quantity of comprehensive fuel additives. If the trial quantity of comprehensive fuel additives provides satisfactory results **351**, a long-term sales agreement **353** is made, and comprehensive fuel additives are delivered **354** on schedule. If results **351** are not satisfactory, the formula may be revised **352**, and another trial order **350** may be placed.

FIG. 35 illustrates an example of steps of supplying comprehensive fuel additives to non-US government political entity customers. First, the additive supplier **360** performs presentations and demonstrations **361** for non-US government entity **362**. Then, non-US government **362** enters into a long-term agreement **363** with the additive supplier **360**. Next, non-US government **362** may send an authorization to purchase **364** comprehensive fuel additives to a non-US refinery **365**. The non-US refinery then sends orders **372** and payments **371** to the additive supplier **360**. Additive supplier **360** then sends product specifications **368**, purchase orders **369**, and payments **370** to a petrochemical manufacturer **367**. Petrochemical manufacturer **367** then sends comprehensive fuel additives **366** to the non-US refinery **365**, preferably with instructions for use. Under appropriate circumstances, such as, for example, when the customer country imports transportation fuel, other delivery points, such as, for example, a fuel depot, fuel storage tank, or fuel station, or pipeline, or warehouse, may suffice. Under appropriate circumstances, such as, for example, where the government directly owns the local refineries, the authorization to purchase **364** may be internal to the non-US government, and orders **372** and payments **371** may come directly from the non-US government **362** to the additive supplier **360**. Under appropriate circumstances, such as, for example, where the additive supplier **360** and the petrochemical manufacturer **367** are the same entity, the flows of orders and payments may be rearranged as appropriate.

Further, many other advantages of applicant's invention will be apparent to those skilled in the art from the above descriptions and the below claims.

Further, many other advantages of applicant's invention will be apparent to those skilled in the art from the above descriptions and the below claims.